Research Note 80-25

DESIGN AND UTILIZATION OF AN INFRARED DATA BASE FOR AN ADVANCED IMAGE INTERPRETATION FACILITY

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Research Institute for the Behavioral and Social Sciences

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A reference information data base for use in an advanced image interpretation facility was designed. The data base utilized three types of organization. Two types of organization utilized primarily representative infrared imagery examples. One type presented views of several targets under one set of acquisition parameters while the second type presented views of one target type under all of the acquisition conditions. The third type of organization utilized primarily textual information. An indexing scheme and retrieval methodology were devised. The experimental data base, with associated

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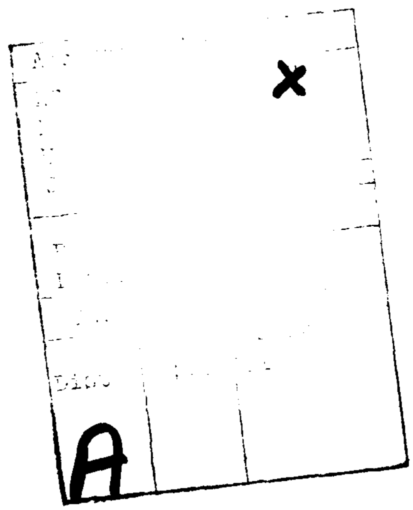
software, was utilized to subject developed concepts to empirical test. One test was designed to ascertain if structured exposure to the data base would increase interpreter proficiency while another test was designed to study the efficiency of such a data base as an aid during interpretation.

It was found that the request formats used on the CRT computer interface could be efficiently utlized with little training. The information presented on the slides in the data base could be easily utilized for training and as reference keys. Structured exposure to the data base in training sessions served to increase the participants' proficiency in identification, at the category level. However, no differences were found in performance between the two organizations of the imagery in the data base.



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Surveillance Systems

DESIGN AND UTILIZATION OF AN INFRARED DATA BASE FOR AN ADVANCED IMAGE INTERPRETATION FACILITY (U)

BRIEF

Requirement:

To analyze the requirements for and develop a reference information data base to be utilized within the context of an advanced tactical image interpretation facility and to subject selected aspects of such a data base to empirical evaluation for training and reference purposes.

Procedure:

In order to define the operational requirements for data base information to aid in the field, a detailed questionnaire was administered to experienced image interpreters.

An analysis was conducted into the organization and content of an infrared data base for reference purposes, together with the mechanics of the construction and display of such a data base. An indexing scheme and retrieval methodology were also devised.

An analysis of the utilization of the data base and auxiliary information, such as flight logs, was performed.

An experimental data base, based upon the analysis, was devised, together with appropriate software to subject the concepts developed in the analysis to empirical test. One test was designed to ascertain if structured exposure to the data base material, in the form of slides, would increase interpreter proficiency while another test was designed to study the efficiency of such a data base as an aid during interpretation.

Findings:

Three types of information organization were delineated for the reference data base. Two portions, containing primarily representative imagery examples differed in the organization of the material, while the third presented a different type of information, primarily textual. The first portion presented a single image of each target type under one set of acquisition parameters, providing simultaneous viewing of several targets under one set of acquisition parameters. The second portion presented images of a single target type under all the acquisition conditions, permitting analysis of the appearance of a single target type under a range of acquisition conditions. The third portion presented detailed target information, primarily textual material concerning target description, employment misidentification errors, effects of weather, and effects of imagery degradation.

An indexing scheme was devised to permit access to keys, prior cover, interpreter reports, or maps.

Procedures for the use of the keys portion of the data base were suggested and related to operational interpretation as well as initial and refresher training.

In the empirical investigation of the utilization of the data base, it was found that the requested formats used on the CRT computer interface could be efficiently handled by the experimental subjects with little training. The information presented on the slides could be easily utilized for training and as keys.

Structured exposure to the data base in training sessions served to increase the participants' proficiency in identification, at the category level. However no differences were found in performance between the use of the two organizations of the imagery in the data base, the use of them together, and not having access to the key material during the course of making an identification, except for the longer time required to use keys.

Utilization of Findings:

Reference material whose value decreases with time, such as prior coverage and previously prepared interpreter reports, should be indexed for rapid retrieval but stored in their original form.

Reference material whose value remains constant, such as maps or key material, should be stored in a unit record format (e.g., a 70 X 100 mm chip) for speed of retrieval, rapid accessioning, and minimizing the bulk of the material to be stored.

Microfilm or similar technology which offers a method of storing large amounts of information easily, should be considered for storing reference information.

To be of maximum usefulness, there should be provision for expansion of the data base, as well as for substitution within the data base.

The empirical demonstration supported the notion that reference information can be indexed, requested, retrieved, and displayed with computer assistance. Though the demonstration was concerned only with the retrieval and display of key information, it may be expected that such a scheme may be used for the retrieval of other types of reference information, such as maps, prior cover, and prior interpreter reports.

DESIGN AND UTILIZATION OF AN INFRARED DATA BASE FOR AN ADVANCED IMAGE INTERPRETATION FACILITY

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INTRODUCTION

Context of the Study

One of the primary missions of the Surveillance Systems Project at the U.S. Army Research Institute is to provide performance data useful for the evaluation of image interpreter techniques, displays, and systems, both present and future.

The present effort has been directed toward the investigation of the utlization of a single reference information data base within the context of an advanced image interpretation facility to improve interpreter performance in two principal ways. In the first, the data base would serve as a source of reference material that the interpreter could use as an interpretation key during operational interpretation. For the second, the data base could serve as a means for providing the interpreter with on-the-job training through systematic exposure to the available data base materials.

This report presents the results of a design analysis to define a method for establishing and utilizing such a reference data based to support interpreter functions within an advanced facility and the results of experimentation to test certain aspects of such a data base for training and reference purposes.

Requirement

The image interpreter in the field must be prepared to interpret imagery in a variety of formats from a number of different sensors. He must be able to detect and identify targets quickly and accurately aand rapidly prepare and disseminate interpretation reports. Prior to assignment to the field, an interpreter is given extensive training in the varied tasks expected of him. However, because of the wealth of knowledge that must be gained in the few short weeks available for training the interpreter cannot be fully prepared in the minute detail needed to meet the multiplicity of demands to be imposed on him in the field.

Experience in South East Asia (SEA) has indicated that there is a need to improve interpreter performance in the detection and identification of targets which may be encountered in a particular area. Interpreters with extensive experience in SEA have indicated that as sufficient time is unavailable during training within CONUS for practice in the identification of a wide variey of COIN and tactical targets, personnel first assigned to units in SEA were generally not prepared to function as fully-qualified image interpreters. Interpreters are usually not familiar with their particular area of operation upon initial assignment. This suggests the need for on-the-job training to supplement that provided in CONUS. Lack of adequate prior practical experience also indicates the need for reference information to support the interpreter during interpretation. Advanced image interpretation facilities may have a capability for storing and displaying a large volume of easily-retrievable reference information. This capability for storing and displaying needed reference information could offer a means for improving interpreter performance in the field.[1]

1

Nelson, A.K. McClure, J. Polgreen and R. Sadacca. Organization and presentation of image interpreter reference and auxiliary information. ARI, TRN 1-3.

Among reference materials, prior cover, interpreter reports and especially maps serve a valuable function in assisting interpreters in the accomplishment of their overall interpretation task. However, this study concentrated on the utilization of the type of information usually considered as interpreter keys.

Reference presenting representative images and detailed descriptions of specific target types or geographical areas constitute interpretation keys. They serve as sources of information which the interpreter can use to aid him in his identification of targets on aerial imagery. Subject keys present representative images of a target type, often under a variety of acquisition conditions with some textual description of the targets. Regional keys, on the other hand, present information on particular geographical areas, describing in detail all target, geographic, geologic, cultural and other information applicable to the particular geographic area.[2]

Recent efforts to aid the image interpreter through the rapid retrieval of reference information have included the development of randomly-accessible unit records, e.g., the Air Force use of Tactical Target Information (TTI) records and the Navy's use of aperture cards in the Integrated Operational Intelligence Center.

A reference information system consisting of unit records that can be accessed randomly and a means for displaying them, in association with a comprehensive indexing procedure for aid in retrieving the records, will permit an interpreter to retrieve the required information rapidly and view it at a convenient location. An advanced facility could utilize a reference information display capability, an indexing scheme for uniquely identifying each unit record, and access to a computer to aid in the rapid identification of unit records meeting the interpreter's retrieval requests.

With the objective of increasing the support provided to the interpreter within an advanced image interpretation facility, a design study was performed to delineate a method for developing and utilizing a reference information data base--with particular emphasis on the use of interpreter key material--for purposes of operational interpretation and on-site training. Certain concepts developed on the basis of the design analysis were then evaluated experimentally.

OBJECTIVES

An advanced image interpretation facility which makes use of a digital computer provides the general context within which this human factors design study was carried out. One assumption upon which this analysis was based was that the computer or computers within the same future system could support peripheral input/output equipment such as a CRT and keyboard combination and that the memory capacity was available to store an index of available reference information against which interpreters could place requests for information.

2

Image Interpretation Handbook, Vo. I, TM 30-245, Naval Reconnaissance and Technical Support Center, December 1967.

The objectives of this analysis were:

1. The definition of the contents of a reference information data base to support operational interpretation requirements as well as on-site training.

2. The analysis of alternative means for organizing the content of the data base.

3. The delineation of a methodology for the retrieval of the desired material.

4. The design of an indexing scheme for accessing information contained in the data base.

5. The analysis of possible procedures for the utilization of the proposed data base for both operational interpretation and training.

6. The delineation of a method for efficient interpreter-computer interaction.

7. The experimental evaluation of the data base for training and reference purposes.

8. The establishment of guidelines for the generation of data base materials at a production facility or in the field.

While the data base utilized in this research was developed to support infrared imagery interpretation, the results may be applied to the interpretation of other types of imagery.

In the development of a scheme for the indexing of the reference information data base, consideration was given for the full range of reference information that should be made available to the image interpreter--maps, prior cover and reports. However, the main emphasis was on infrared reference material that would be stored in a unit record format for projected display to the interpreter.

PROBLEM DEFINITION

Systems to Aid the Image Interpreter

The history of aerial surveillance has seen the development of sensors which have significantly increased the types and amount of imagery that may be acquired. This has resulted in a distinct imbalance between the capability to collect imagery and the ability to process it to derive the required intelligence. However, recent developmental efforts have been directed toward the support of the image interpreter in the field. The Army has provided interpreters in SEA with tactical image interpretation facilities on a limited basis. Other services have similarly developed systems which include equipment designed to expedite the efforts of the image interpreter, e.g., the

Navy's Integrated Operational Intelligence Center (IOIC), and the Image Interpretation Segment of the Air Force Tactical Information Processing and Interpretation (TIPI) system.

The development of these systems reflect an attempt to assist the interpreter through improved imagery display devices with multi-roll capability (either rear-lighted or rear-projection), mensuration aids (for computer-aided calculations), storage and display of reference material, and improved communications (reporting) equipment. The Image Interpretation Segment (IIS), the component of the Air Force Tactical Information Processing and Interpretation (TIPI) System designed to provide direct support to the image interpreter, represents the most recent effort in this direction and is currently undergoing evaluation by the Air Force.

A feature found in the IIS is the CRT-keyboard combined or used as the Query Response and Report Composer Unit (QR/RCU). The QR/RCU serves as the interface between the interpreter and the system computer, allowing rapid communication of a wide variety of data between computer and interpreter. The keyboard allows the interpreter to communicate directly with the computer. The CRT serves as the display for computer-generated information in addition to the display of information to be inputted to the computer. The CRT display may be used to present full page reporting formats with blanks to be filled in by the interpreter.

In an advanced facility in the conceptual state of development there are to be storage and semi-automatic display capabilities for a wide variety of reference information--including maps, keys, reports, and prior cover.

From a central store of reference information, mostly in the form of 70 X 100mm chips, the interpreter will be able to select desired support information for viewing. With computer assistance in identifying the information within the data base that meets his special requirements, the interpreter can select the appropriate material; develop his own unique, special-purpose data base; view the material as he desires; and, when he has completed his particular assignment, return it to the central storage facility.

The proposed facility should represent a further augmentation of state-of-the-art equipment to assist the image interpreter in accomplishing his principal interpretation activities. The purpose of the present effort has been to consider methods by which capabilities to be available within the advanced system can most effectively be utilized.

Determination of Data Base Requirements

In order to define operational requirements for data base information to aid in the field, an initial effort in this analysis was the administration of a detailed questionnaire to experienced image interpreters. This questionnaire was designed to obtain information relevant to data base requirements for use both as infrared key material and training materials. With respect to training considerations, the questionnaire was designed to determine field interpretation performance goals and the means that would be appropriate to achieve these goals. In addition, an assessment was made of current operational problems and interpreter performance deficiencies correctable by improving training.

The requirements for interpreter keys were approached in terms of what problems presently exist in the field, and what materials have been found to provide assistance in the proper identification of tactical targets.

The questionnaire was administered to two groups of experienced interpreters. One group was composed of seven senior instructors involved in the conduct of the Image Interpretation Course presented by the Aerial Reconnaissance and Surveillance Committee, Intelligence School, Fort Holabird, Maryland. This group was selected because of their obvious familiarity with instructional procedures and close contact with students and their capabilities and requirements. Of the seven, five were graduates of the officer's interpretation course at Fort Holabird and five had been directly involved with IR interpretation in Southeast Asia. All were experienced and familiar with operational requirements, capabilities, and limitations of IR systems.

The second group consisted of six interpreters who where all civilians with a diversity of Army, Air Force, or combined Army/Air Force experience. Two were graduates of the interpreter course at Fort Holabird; two had attended Air Force image interpretation courses. All had tours of duty in South Vietnam (either as servicemen, civilians, or both) and, at the time of the interviews, were directly involved with the interpretation or analysis of SEA imagery.

Although some differences were found between the results of the two groups which completed the questionnaire, these discrepancies were slight and the results discussed here will be a compilation of data from both groups.

Perhaps the most significant finding derived from the questionnaire was the observation that present formal school training, while apparently adequate in imparting technical information concerning the IR sensor and the manner in which it images targets, does not provide the interpreter with sufficient exposure and practice on imagery relevant to the operational setting. The results indicated that a lack of knowledge or familiarity with both target signatures and with acquisition parameters was a source of interpretation errors with newly graduated interpreters. Furthermore, there was general agreement that it took approximately six months for new interpreters to acquire sufficient knowledge of these factors for them to make accurate and confident interpretations. More specifically, in response to a question asking what target signature characteristics tend to cause the most errors, respondents reported that target location and surroundings were the most troublesome. In response to a similar question concerning acquisition parameters, altitude, target type, and environmental conditions were most frequently mentioned.

Recommendations for improving knowledge of target signatures were varied; however, practical exercises, non-target instruction, target dossiers, and instruction in enemy habits were mentioned as being potential aids. When queried as to the usefulness of keys for target signature analysis, comparative keys with sections on environmental conditions, time of day, equipment malfunctions, and target signatures were mentioned. It was further recommended that keys for this purpose contain representative photo and SLAR imagery in addition to infrared.

It appears that a large amount of variability exists in the requirements for the level of detail in operational interpretation. Detail requirements seem to be dependent on the interpreter organization and who requests the mission. Additional training in the discriminating factors of target signatures, geographic and cultural conditions, and on discriminating targets from nontargets was recommended. Response concerning the value of keys in improving the interpreter's capabilities for greater level of detail were somewhat divergent and inconclusive.

Collateral information was judged to be a valuable aid during interpretation. Present utilization is highly variable among units and ranges from no collateral information used in some cases to regular and extensive usage of prior coverage, maps, and photographic imagery in others. The most valuable types of collateral information appeared to be prior coverage, prisoner interrogation reports, and feedback from the mission requester. There appears to be no established procedures for routinely forwarding this information to interpretation units.

Practical exercises were judged to be an effective tool in increasing proficiency in all areas examined. The general feeling was that they should be structured in the most realistic way possible with input, interpretation requirements (such as level of detail required) and output requirements (reports) being as close to the "real world as possible." One recommendation for a practical exercise was as follows:

1. Provide the trainee with imagery, pilot's photo log, and blank report forms.

2. II would obtain appropriate maps for plotting.

3. Quick review of imagery for hot items.

4. Annotate suspicious returns and plot.

5. Determine probable identification of suspicious items.

6. Write report.

In summary then, it appears that a rather sizable performance deficiency is generaly exhibited by interpreters newly assigned to the field. A period of approximately six months of on-the-job experience is required for these new interpreters to establish acceptable proficiency in the interpretation of infrared imagery. Practical exercises structured as realistically as possible are the prime recommendations to speed this process. Several types of keys were recommended.

DATA BASE STRUCTURE AND DEFINITION

Data Base Definition

When considering the full range of reference information that would comprise data base, a matter of immediate concern is the most appropriate storage medium for each type of information. There are two major categories of reference information. Prior imagery coverage and reports on the results of previous missions represent information that, for the most part, has transitory value; the value of key material and maps, on the other hand, are not situation-specific but have general application over a wide variety of situations and their value will generally not decrease with the passage of time.

In the tactical situation, for reference material whose value decreases as a function of time, there is little reason to consider making a permanent record of this material. Prior coverage and previously prepared reports may prove of great value to trace the enemy's behavior, but the relevance of such information drops off sharply as the enemy's position changes and new imagery is acquired. What is needed for assessing change in the deployment of enemy forces is a means for quickly retrieving recently acquired information it its originals form. If properly designed and utilized, a continually updated index of such materials will permit the rapid accessioning of the most relevant information. For example, if a computer index is continually updated with information on the contents of each interpreter report as it is filed, the interpreter may subsequently use this index to locate the number of a report detailing, for instance, equipment found at a particular location at a certain time.

In the case of prior imagery coverage, a request against the index for prior coverage based on information contained in the pilot's flight log, and/or code matrix block (CMB) for the current flight, giving location, time of take, altitude, etc., would permit the rapid accessioning of the appropriate roll of previously acquired film from film storage. Location data in the index should help the interpreter locate areas of the film with sufficient precision to reduce the search time within a roll to a minimum, particularly if CMB/computer search is linked with the roll-film device.

Maps and key material are standard reference materials that may be considered as permanent, with changes required only when new, more accurate maps are generated or new key material is developed. The conversion of maps and typical key material to a unit record format, where material is presented as separate, discrete items, offers the opportunity for reducing the bulk of the required materials and permits the easier accessing of desired items. As a unit record consists of a viable unit of information which can be displayed alone, the conversion of these types of reference materials to this general format would permit the random accessioning of information through the intermediate use of a manual or computerized index describing the content of each unit record.

By reducing all maps to separate photographic unit records large amounts of information may be stored on a limited number of photographic images. Display equipment may be used to enlarge these reduced unit records to a proper size for viewing.

The question that now arises is concerned with the actual character of the unit record. Present technology permits the reduction of material in unit record format to an extremely small size, as may be seen in the use of microfiche, where sixty to ninety-eight 11mm x 16mm images may be placed on a single 114mm x 147mm sheet. Even larger reductions, permitting the placing of up to 9,000 images on a single sheet of film, can be achieved for limited applications.

Tri-service agreements require that standard Army Map Service maps will be reduced to 70mm x 100mm "chips". The selected format for the presentation of maps would argue for the selection of this format for the display of other reference material as well.

Although the use of the 70mm x 100mm format for key material will permit the "packing" of more than one item of information on a single chip, as will be seen in subsequent sections, this format may not necessarily represent the most effective format, for several reasons.

With only a limited amount of information on each chip, a large central storage facility would be required. However, if information could be reduced to a microform format with, say, 60 items on a single piece of film, the size of the data store would be further reduced. A display unit at each interpreter station with a complete complement of material would permit each interpreter to view any items in the data base without interfering with the requirements of other interpreters. A problem that must be considered in the case of a single central storage area containing one set of reference materials serving a number of users is that two or more interpreters may simultaneously have need for the same information. Though priorities for utilization of the data base could be established within each facility, no general scheme could be developed that would always prevent such potential conflict. The idea of providing within central storage two complete duplicate sets of materials or even duplicate portions of the data base does not appear to be cost-effective, as there would undoubtedly still be sections of the data base that would be required at the same time by more than one-interpreter, while other sections may go relatively unused. Procedures based on priorities defining the sequential use of the references are thus indicated.

Although microfiche display equipment at each interpreter station represents an alternative method to the 70mm x 100mm map chip format for displaying reference material to the interpreter, the focus on the 70mm x 100mm format led to its selection for the key reference material for this analysis.

The 70mm x 100mm format can be used to display fairly large amounts of information on a single slide. Key material consisting of text and representative images may be reduced onto the 70mm to 100mm format for subsequent display at normal or slightly enlarged scale. Factors affecting the amount

of information that can be "packed" on a single slide include the size of the piece, or "slice", of original imagery used, the size of the display screen, the required resolution at the screen, and the amount of magnification desired. The following example involving the display of reference information relevant to IR imagery interpretation should serve to indicate the factors determining the amount of information that can be put on a single slide.

To produce a chip, original positive and/or negative "slices" of original imagery could be combined with required textual material in a 7" X 10" format and the chip produced at a 3X overall reduction. Using a 9X enlargement on subsequent display, the presentation would fill a 21" X 30" screen at an enlargement of 3-times the size of the original imagery. Assuming adequate illumination and average contrast, a line scan image, (i.e., IR) having a line width of approximately .601 inch (39 lines/mm) would produce a screen presentation of approximately 12 lines per millimeter. This is sufficiently close to typical rear projection screen resolution of 10 lines per millimeter to avoid loss of any significant information, based on normal processing and reproduction of the original image during reduction to chip format.

If representative imagery were used to make up a chip and the pieces of imagery placed so that none fell on the extreme edges of the 30" X 21" viewing surface, a maximum of 12 image "slices" with an original size of 1.25 X .125 inches would fit on each chip together with limited labeling and annotation.

Content and Organization of Data Base

Content and Organization of Key Information. Initial direction for the delineation of the content and organization of this portion of the data base came from the questionnaire results previously discussed, which indicated the general nature of performance deficiencies noted in the field. The fact that the data base was to be used for purposes of training as well as operational interpretation also influenced the proposed design of this portion of the data base.

The proposed key portion of the data base is organized into three sections. Two of the sections represent different ways of organizing a body of representative imagery pertinent to target identification while the third section includes detailed information in the form of text and images on each target type to be studied. Thus, two of the sections differ in the organization of the representative imagery presented, while the third presents a different type of information from the other two -- detailed information on target characteristics, the environment in which each target is found, the nature of potential misidentification errors, and factors influencing the imaging of targets.

The next two subsections of this report describe the content and organization of the key information portion of the proposed data base and the format requirements for its display.

Representative Imagery. Information in the first two sections of the data base is composed of a store of imagery (with appropriate descriptive annotations) varying along a number of specific dimensions. An example of how infrared imagery could be organized is as follows:

Dimension	Variations
Target Type	Aircraft Boats Emplacements Fires Personnel Structures Vehicles
Time of Acquisition	Day Evening Night
Altitude	500 feet 1000 feet 2000 feet
Detector Cell (when applicable)	Long Wave Length Short Wave Length

Given imagery for a number of target types under a variety of acquisition parameters, it is possible to organize the same collection of representative images in two ways, as described below.

The first of these results from structuring the imagery to provide one image of many targets under one set of acquisition parameters (Parameter Accession). This method of organization can be illustrated by referring to Figure 1, choosing one set of acquisition parameters (for example, Day, 500 feet, Short Wave Length), and reading down the column. An example of how information would appear on a single chip is shown in Figure 2. This method, then, provides examples of the appearance of many targets under one set of acquisition parameters.

The second type of organization structures the imagery so that the appearance of one target type is presented under all the acquisition conditions (Target Accession). Referring again to Figure 1, this method of organization can be illustrated by choosing one target type (such as aircraft) and reading across the matrix. An example of the material as it would be presented under such an organization is shown in Figure 3. The first method of organization permits the interpreter to compare the signatures of a number of targets under the same acquisition parameters more or less simultaneously. The second method of organization allows the interpreter to study a single target more intensively under a number of acquisition conditions.

TARGET CATEGORY AND SUBCATEGORY*		DAY						EVENING						NIGHT					
		500'		1000'		2000'		500'		1000'		2000'		500'		1000'		2000'	
		SWL	LWL	SWL	LWL	SWL	LWL	SWL	LWL	SWL	LWL	SWL	LWL	SWL	LWL	SWL	LWL	SWL	LWL
AIRCRAFT (A/C)	LT. OBS.																		
	HELO.																		
	FIGHTER																		
BOAT	BARGE																		
	JUNK																		
	SAMPAN																		
	SHIP																		
EMPLACEMENT	ARTY																		
	BUNKER (SS)																		
	FOX-HOLE																		
	M. GUN																		
	MORTAR																		
	MISSILE																		
	TRENCH																		
FIRE	CAMPFIRE																		
	STOVE																		
PERSONNEL	SINGLE																		
	GRP. DEPLOYED																		
	GRP. CONCENT'D																		
STRUCTURE	BRIDGE																		
	BUNKER (SURF)																		
	HUT																		
	POL TANK																		
	TENT																		
VEHICLE	HEAVY MOTR'D																		
	LIGHT MOTR'D																		
	INDIGENOUS																		

*SWL - SHORT WAVELENGTH DETECTOR
LWL - LONG WAVELENGTH DETECTOR

FIG. 1 REPRESENTATIVE INFRARED PORTION OF THE DATA BASE

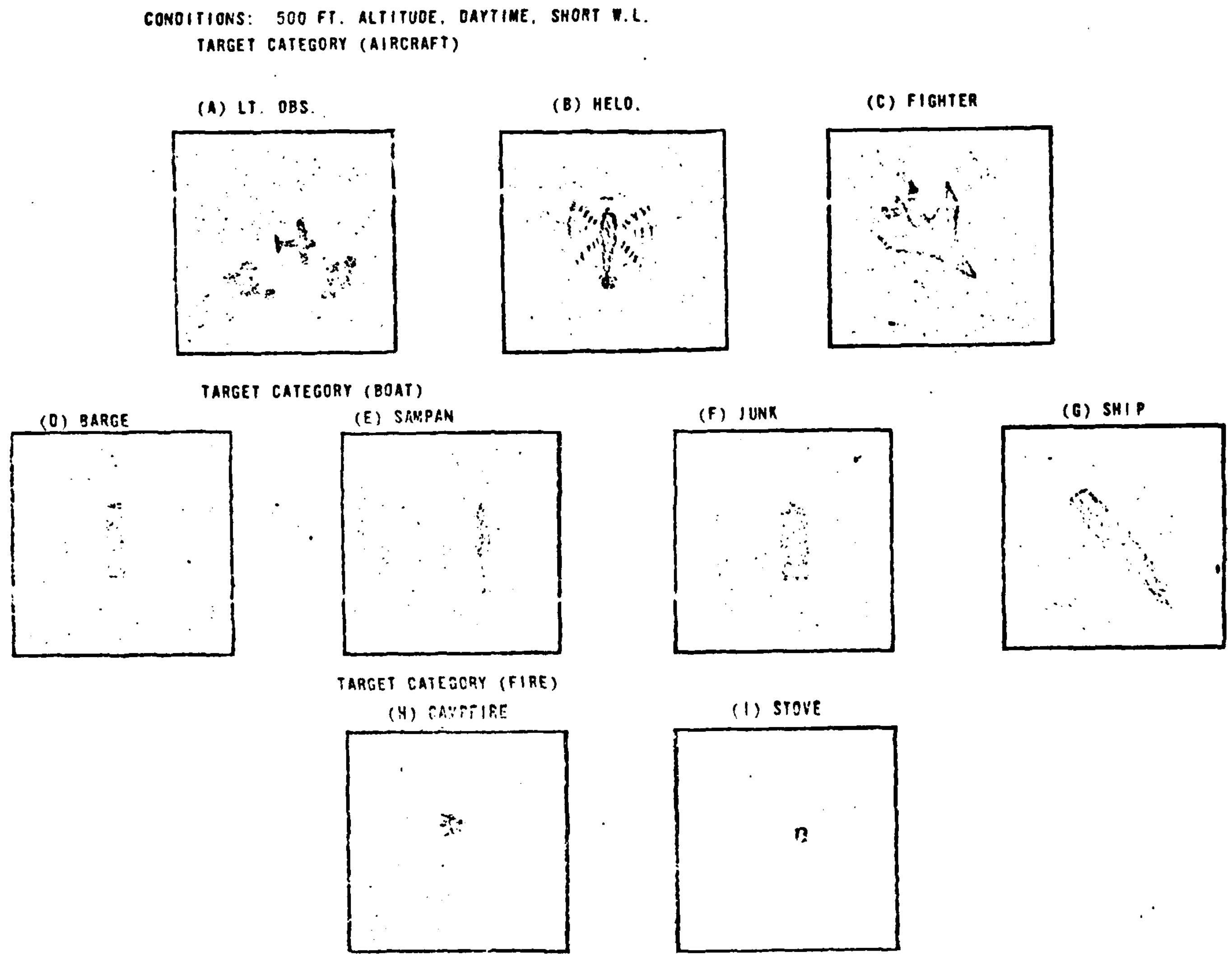

FIG. 2 EXAMPLE OF PARAMETER ACCESSION CHIP ORGANIZATION

AP3353

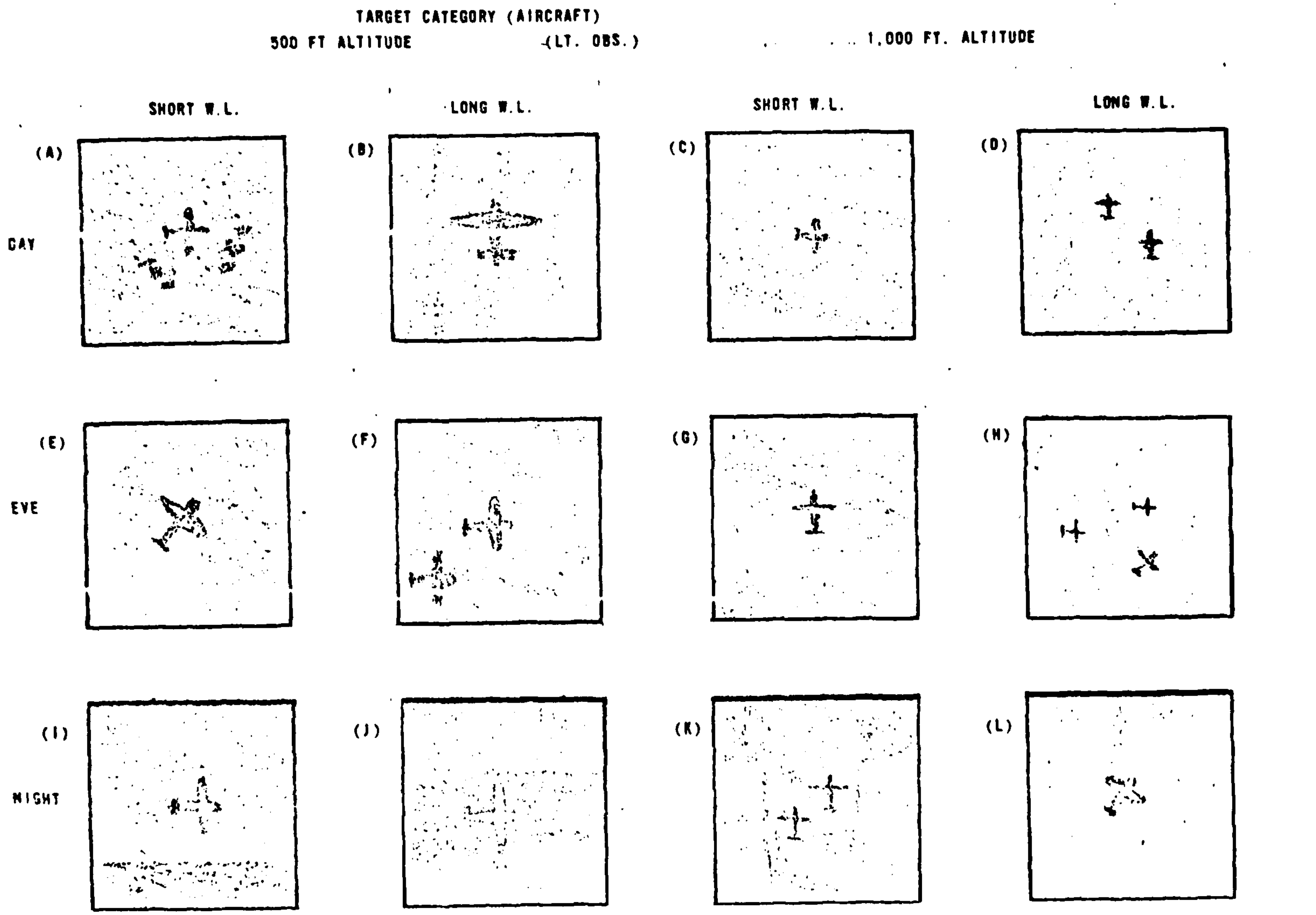

FIG. 3 EXAMPLE OF TARGET ACCESSION CHIP ORGANIZATION

KP3354

Detailed target Information. In addition to representative imagery, as described above, an interpreter could be provided with more detailed information on each target type he is likely to encounter to aid him in the precise identification of targets and for potential use as training materials. The following pages describe five types of information that could be provided and a proposed method for structuring this information. This section of the data base, in contrast to the two previously-described sections, contains textual material and sketches, as well as representative imagery. The five types of information include: target description, enemy employment, misidentification errors, weather, and imagery degradation.

The section titled Target Description contains three subcategories of information which describe: (1) the physical characteristics of the target in terms of size, shape and material composition (2) the basic signatures of the targets as they appear on IR, SLAR or photographic imagery , and (3) cues to identification of the target such as typical location and associated activities.

The section on Enemy Employment contains information on each target type in terms of: (1) the cultural environment in which it is likely to be located, (2) counter-reconnaissance measures employed to prevent its detection, (3) the target pattern in which multiple occurrences of each target type are found, (4) complex target arrays which contain the subject target in combination with other targets; and (5) an assessment of the military significance of the target.

The section concerning Misidentification Errors consists primarily of representative imagery of both natural and man-made features likely to be incorrectly identified as the subject target. Examples of each would be shown under different acquisition conditions.

The effects of Weather on the imaging of each target type constitutes another section describing the effects of atmospheric conditions such as clouds, fog, rain, humidity, temperature, and wind on target imaging. Imagery illustrating these variables combined with textual material makes up this section.

Characteristics of image degradation could be described in terms of two primary equipment-oriented causes of degradation -- when equipment capabilities are exceeded and for equipment malfunctions.

Table 1 presents an outline for the content and organization of a portion of the data base concerned with the detailed description of targets.

Index

Indexing is generally described as the function which "tags" information so that subsequent retrieval and manipulation can be performed against this information. Therefore, an index identifies or characterizes the content of the information which it represents.

TABLE 1 EXAMPLE OF A PROPOSED OUTLINE OF THE DETAILED TARGET INFORMATION PORTION OF DATA BASE

AP10266

1. TARGET DESCRIPTION

    1.1 TARGET CHARACTERISTICS

        1.1.1 TARGET SUBCATEGORY "1"

            1.1.1.1 SIZE (TEXT)

            1.1.1.2 SHAPE (SKETCH)

            1.1.1.3 MATERIAL COMPOSITION (AERIAL AND GROUND PHOTO)

. . . .

        1.1.n TARGET SUBCATEGORY "n"

    1.2 BASIC SIGNATURES

        1.2.1 TARGET SUBCATEGORY "1" -- (TEXT AND IMAGERY)

            DESCRIPTION OF HOW TARGET IMAGES ON IR

. . . .

        1.2.n TARGET SUBCATEGORY "n"

    1.3 CUES FOR IDENTIFICATION

        1.3.1 TARGET SUBCATEGORY "1" -- (TEXT AND IMAGERY)

            PHYSICAL AND/OR CULTURAL FEATURES WHICH AID DETECTION AND IDENTIFICATION

. . . .

        1.3.n TARGET SUBCATEGORY "n"

2. ENEMY EMPLOYMENT

    2.1 CULTURAL ENVIRONMENT

        2.1.1 TARGET SUBCATEGORY "1" -- (TEXT)

            ENVIRONMENT AND SURROUND IN WHICH TARGET IS MOST LIKELY TO BE LOCATED

. . . .

        2.1.n TARGET SUBCATEGORY "n"

    2.2 COUNTER RECONNAISSANCE MEASURES

        2.2.1 TARGET SUBCATEGORY "1" -- (TEXT, SKETCH AND IMAGERY)

            MEASURES SUCH AS CAMOUFLAGE EMPLOYED TO AVOID DETECTION

. . . .

        2.2.n TARGET SUBCATEGORY "n"

    2.3 TARGET PATTERN

        2.3.1 TARGET SUBCATEGORY "1" -- (TEXT)

            SPACING OR PATTERN IN WHICH TARGETS ARE LIKELY TO BE FOUND

. . . .

        2.3.n TARGET SUBCATEGORY "n"

    2.4 COMPLEX TARGET ARRAY

        2.4.1 TARGET ARRAY "1" -- (TEXT, SKETCH, PHOTO, AND IMAGERY)

            DESCRIPTION OF MULTIPLE TARGET COMPLEXES SUCH AS AIRFIELDS, BASE CAMP, ETC.

. . . .

        2.4.n TARGET ARRAY "n"

TABLE 1 EXAMPLE OF A PROPOSED OUTLINE OF THE DETAILED TARGET INFORMATION PORTION OF DATA BASE (CONT'D)

AP10268-2

2.5 MILITARY SIGNIFICANCE ASSESSMENT

2.5.1 SECURITY - (TEXT)

2.5.2 PROXIMITY TO FRIENDLY FORCES - (TEXT)

2.5.3 PROXIMITY TO OTHER ENEMY FORCES - (TEXT)

2.5.4 CHARGE DETECTION - (TEXT)

3. MISIDENTIFICATION ERRORS

3.1 NATURAL FEATURES

3.1.1 NATURAL FEATURE ''1'' - (IMAGERY AND TEXT)

3.1.1.1 IMAGERY - ONE EXAMPLE AT EACH OF THREE ALTITUDES (TIME OF DAY AND DETECTOR CELL CONSTANT)

3.1.1.2 IMAGERY - ONE EXAMPLE OF EACH OF THREE TIMES OF DAY (ALTITUDE AND DETECTOR CELL CONSTANT)

3.1.1.3 IMAGERY - ONE EXAMPLE OF EACH OF TWO DETECTOR CELLS (ALTITUDE AND TIME OF DAY CONSTANT)

. . . .

3.1.n NATURAL FEATURE ''n''

3.2 MAN-MADE OBJECTS

3.2.1 OBJECT ''1''

3.2.1.1 IMAGERY - ONE EXAMPLE AT EACH OF THREE ALTITUDES (TIME OF DAY AND DETECTOR CELL CONSTANT)

3.2.1.2 IMAGERY - ONE EXAMPLE OF EACH OF THREE TIMES OF DAY (ALTITUDE AND DETECTOR CELL CONSTANT)

3.2.1.3 IMAGERY - ONE EXAMPLE OF EACH OF TWO DETECTOR CELLS (ALTITUDE AND TIME OF DAY CONSTANT)

4. WEATHER

4.1 CLOUDS - (IMAGERY AND TEXT)

4.2 FOG - (IMAGERY AND TEXT)

4.3 HUMIDITY - (IMAGERY AND TEXT)

4.4 RAIN - (IMAGERY AND TEXT)

4.5 TEMPERATURE - (IMAGERY AND TEXT)

4.6 WIND - (IMAGERY AND TEXT)

5. IMAGERY DEGRADATION

5.1 EFFECTS OF EQUIPMENT CHARACTERISTICS

5.2 EFFECTS OF EQUIPMENT MALFUNCTIONS

Prior to determining an index strategy, a set of criteria was specified to help define the characteristics of the proposed index.

1. Simplicity

   The index should be simple from the user's standpoint, so that the scheme used does not require extensive training, yet produces information quickly and efficiently. Also, the index should be compatible with the capabilities of the input/output device so that reliance on external index guide (hard-copy listing) would be minimized.

2. Adequacy and Flexibility

   The index should reflect the characteristics of the film chip file to be retrieved; should permit updating and purging; and should accommodate a variety of files (infrared imagery, image interpreter reports, prior cover, and maps) and formats (text, imagery, and sketches).

3. Mnemonic Qualties

   The index should include some mnemonic features such as recognizable characters or descriptors. This quality would help speed up subject familiarization with selected file characteristics.

4. Back-Up Index

   An eye-readable index on each data base chip should be available in case of mechanical failure of the computer, to handle assignment errors, and to use in case of accidents, e.g., dropping chips.

Based on the criteria cited above, it appears that the most feasible computer indexing technique for a TIIF data base would be the actual contents (field entries) of the computer record as stored. Among the reasons for proposing this form of indexing are: (a) it meets the criteria of simplicity, flexibility and mnemonic qualities, (b) users who may assist in preparing new data for input would already be familiar with the record structure (from retrieving information), and (c) external indexing aids (look-up tables) would be minimized. As indicated previously four files will be maintained; keys, prior cover, reports, and maps.

Using this form of indexing, the characteristics of the digital record and the index itself can be treated together since they are in fact the same. These characteristics and index samples, over the range of the four subfiles are depicted in Figure 4. The makeup of each of the four subfiles is shown in Figure 5. This figure illustrates the varying record lengths required for each subfile. It also indicates the flexibility of the storage formats. For example, blank fields have been interspersed for the possible addition of new

FIELD NAME	SUB-FILES				TYPE FIELD	NR. CHAR. STORED	TYPE CHAR	EXAMPLE
	KEYS	P.C.	RPT.	MAP				
FILE	X	X	X	X	FNR*	1	A**	R = REFERENCE FILE
CHIP NR/BLOCK	X	X		X	FNR	5	A/N	0123A
SOURCE	X	X			FNR	1	A	I = IR; P = PHOTO
SENSOR	X	X			FNR	1	N	1 = RS-10; 2 = AAS-18
DETECTOR	X	X			FNR	1	A	S = SHORT WAVE LENGHT
ALTITUDE	X	X			FNR	3	N	015 = 1500 FEET
TIME OF DAY	X	X			FNR	1	A	D = DAY; N = NIGHT
FILTER	X	X			FNR	2	A	LP = LONG PASS
ASPECT ANGLE	X	X			FNR	1	N	1 = 10 DEGREES; 2 = 20 DEGREES
IMAGE SCALE	X	X			FNR	3	N	010 = 1:10,000
COVER	X	X			FNR	2	A	MD = MED. COVER
TERRAIN	X	X			FNR	2	A	LD = LEVEL DRY
FILM TYPE	X	X			FNR	1	N	1 = BLACK AND WHITE (PANCHROMATIC)
IMAGE QUALITY	X	X			FNR	1	A	G = GOOD; E = EXCELLENT
CHIP FORMAT	X				FNR	1	N	2 = IMAGERY; 3 = IMAGERY SKETCH
INFORMATION CAT.	X				FNR	2	N	01 = TARGET DESCRIPTION
INFORMATION SUB-CAT.	X				FNR	2	N	02 = BASIC SIGNATURE
TARGET CAT./NR.	X				FR	4	N	0101 = AIRCRAFT (1)
TARGET SUB-CAT./NR.	X				FR	4	N	0301 = FIGHTER (1)
REPORT NUMBER		X	X		FNR	4	N	0328
DATE (DAY-MONTH-YEAR)		X	X		FNR	6	N	110469
MISSION/SORTIE		X	X		FNR	4	N	0116
COORDINATES		X	X	X	FNR	10	A/N	GH43606940
ROLL NUMBER		X			FNR	3	N	057
TARGET IDENTIFIER		X			FNR	11	A/N	DHIN BRDG 2
MAP SCALE				X	FNR	3	N	250 = 1:250,000
MAP SERIES				X	FNR	4	A/N	V778
MAP NUMBER				X	FNR	11	A/N	7062 IV-SE

* FNR - FIXED NON-REPEATING
FR - FIXED REPEATING
** A - ALPHABETIC CHARACTER
N - NUMERIC CHARACTER

FIG. 4 FIELD CHARACTERISTICS TABLE

AP102 1

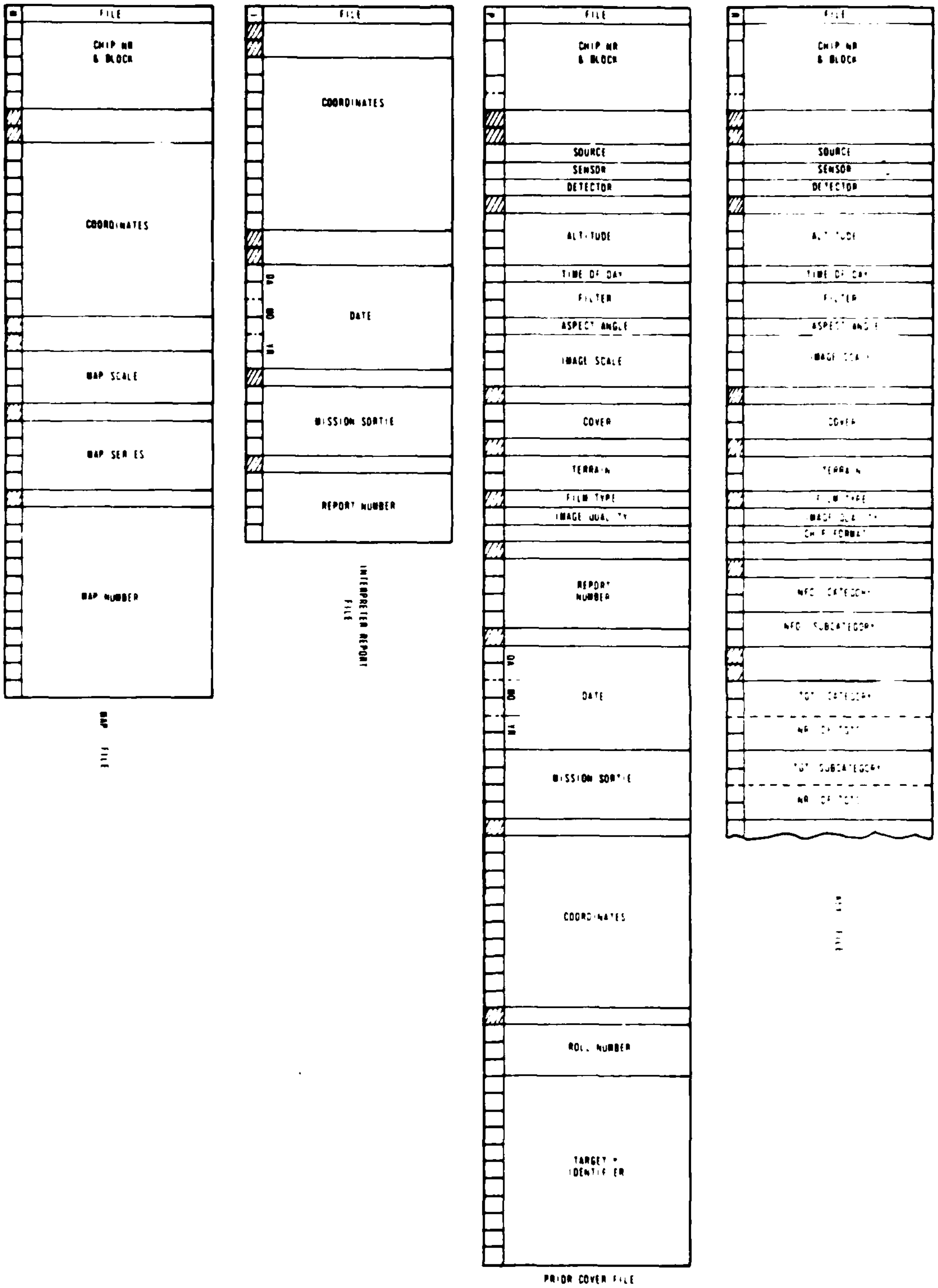

FIG. 5 FILE INDEXING SCHEMES

data or the expansion of fields already specified. As a further example of flexibility, the Prior Cover format will accommodate references to roll imagery or chips made from the rolls.

To illustrate the specific application of the index, Figure 6 shows the makeup of the digital index for a hypothetical IR record within the Keys File. Multiple (repeating) targets would simply be entered at the end of the record.

The following listing explains the entries shown in the sample IR record (Figure 6).

Field Number	Field Name	Sample Entry (Index)	Entry Explanation
1	File	R	R indicates that the record is part of the Reference File
2	Chip Number and Block Code	0123A	0123 is the unique number identifying the chip containing this record (image). "A" denotes that the first image on the chip is the one represented by this computer record.
3	Source	I	I is the code for IR (Infrared) rather than S (SLAR) or P (PHOTO).
4	Sensor	2	The digit "2" represents the AAS-14 sensor.
5	Detector Cell	S	The "S" is a mnemonic for Short Wave Length.
6	Altitude	015	Represents 1,500 feet. The last two digits (hundreds) are deleted.
7	Time of Day	N	"N" denotes Night.
8	Filter	LP	These letters denote that a Long Pass filter was used.
9	Aspect Angle	2	The digit "2" denotes 20 degrees. This entry is made in increments of 10 degrees.
10	Image Scale	010	Represents 1:10,000 scale. The last three digits (thousands) are deleted.
11	Cover	MD	The letters MD refer to Medium Cover.
13	Film Type	1	The digit "1" denotes Black and White Film.
14	Image Quality	E	The letter "E" stands for Excellent quality
15	Chip Format	2	2 is the code denoting the chip makeup as imagery (no text or sketches).

FIELD NUMBER	FIELD NAME	SAMPLE ENTRIES (INDEX)
1	FILE	R
2	CHIP NUMBER AND BLOCK CODE	0
		1
		2
		3
		A
3	SOURCE	I
2	SENSOR	2
5	DETECTOR CELL	S
6	ALTITUDE	0
		1
		5
7	TIME OF DAY	N
8	FILTER	L
		P
9	ASPECT ANGLE	2
10	IMAGE SCALE	0
		1
		0
11	COVER	M
		D
12	TERRAIN	L
		D
13	FILM TYPE	1
14	IMAGE QUALITY	E
15	CHIP FORMAT	2
16	INFORMATION CATEGORY	0
		1
17	INFORMATION SUBCATEGORY	0
		2
18	TARGET CATEGORY AND NUMBER OF TA GETS	0
		1
		0
		1
19	TARGET SUBCATEGORY AND NUMBER OF TARGETS	0
		3
		0
		1

FIG. 6 MAKE-UP OF COMPUTER RECORD FOR IR IMAGERY SHOWING SAMPLE ENTRIES (INDEX)

AP 10??

Field Number	Field Name	Sample Entry (Index)	Entry Explanation
16	Information Category	01	The entry "01" denotes that the image contains Target Description information.
17	Information Subcategory	02	The entry "02" denotes that the target description (field 16) appears as a Basic Signature, (as opposed to Cues to Identification or Target Characteristics).
18	Target Category and Number of Targets	0101	The first 2 digits indicate that the target is an Aircraft; the second 2 digits indicate that only one aircraft is contained on the imagery.
19	Target Subcategory and Number of Targets	0301	The first 2 digits (03) indicate that the aircraft is a fighter; the second 2 digits (01) indicate that there is only one fighter.

NOTE: Fields 18 and 19 would be repeated for all other targets contained on *block (image) A of chip* 0123. In the record illustration, Figure 6, it is assumed that no other targets were contained on the image.

Input media could include punch cards, paper tape, magnetic tape, or the keyboard/CRT. The actual medium selected will be a function of the precise hardware configuration selected. For example, the input medium for CONUS-generated data might be paper or magnetic tape or punched cards. Field-generated inputs, on the other hand, might be via punched cards or direct entry using a CRT.

Unlike the other three files, the Key File records would be variable length since the target Category and Target Subcategory fields are repeating fields. These two fields would be repeated for as many targets as are contained in the image on the chip.

The format for Prior Cover information has been designed to accommodate digital reference to rolls of imagery obtained in previous reconnaissance flights and selected chips made from these rolls.

When coding (indexing) roll imagery, the chip number and target identification fields are left blank. The coordinates field would contain the gross coordinate area covered by the mission/sortie.

If chips are made of selected targets within a roll of imagery, information pertaining to these chips is coded for computer input by using the same format as used for roll imagery reference with three additions: (a) a chip number field is used, (b) more detailed coordinates are used to pinpoint the target location, and (c) a target identifier is assigned to the target, e.g., DHIN BRIDGE.

The format for indexing Interpreter Reports would enable computer search and retrieval for accessioning hard copy reports stored in file cabinets. This index may also be applied, with modifications as required, for retrieving these reports stored on some other medium.

The map file would consist of a digital index to maps which have been reduced to 70 X 100mm chips. The format for recording references to these chips could include map identifiers such as coordinates, map series, map number, and map scale.

Four separate storage records corresponding to each of the four files appears reasonable. There are several reasons for considering four storage records instead of just one. First, it facilitates retrieval, especially if serial searching is to be employed. In this case, three of the four subfiles are eliminated from the search during any given query since the FILE field is likely to be the primary search criterion. Second, data compression routines (to eliminate unused fields in a given record) would not be a problem since each storage record would be tailored to a specific subfile format. Third, a review of the fields comprising each of the four subfiles indicates that there are no fields common to all files (except the first field which indicates the file).

DATA BASE UTILIZATION

The previous section has discussed possible indexing schemes for the four reference information data base subfiles, a proposed content and organization of the keys portion of the data base, an indexing method for the retrieval of information from the data base, and a discussion of alternatives for development of the data base. The present section is directed toward a discussion of ways in which the keys portion of the data base may be effectively used to provide aid to the interpreter during operational interpretation and for initial and refresher training.

OPERATIONAL INTERPRETATION

Utilization of Auxiliary Information

Auxiliary information derived from Mission Requests, pilot's flight logs, and code matrix block information -- pertaining to a particular operational mission -- may be utilized by the interpreter in preplanning his approach to

the interpretation to perform the actual interpretation, and to prepare his report after interpretation. This type of information may not be located within the data base but may dictate how the data base will be utilized.

Mission Request. The Mission Request should be an integral part of the interpreter's information, used primarily for planning his interpretation approach and the data base material he will assemble. It should also be used during reporting as a check to assess the degree of fulfillment of mission objectives.

Although the particular format and size of a Mission Request may vary from a simple sentence to a multi-page message, three essential items are contained in a request which will enable the interpreter to plan his interpretation and data base requirements. The three elements are time, place and purpose. A sample mission request, may then take the form of:

> "Reconnaissance of Route 121A between coordinates ZZ342697 and AA449763 is required prior to 0030Z 12 Dec 68 to confirm suspected enemy armored column movement."

or

> "Locate suspected enemy CP in XT47 area prior to commencing Operation BRICKHOD."

Other types of requests may also specify primary and secondary information needs, specific scales and/or altitudes to be flown, sensors to be used, or other special flight parameter requirements. The Mission Request provides the essential information for both the planning and execution of the mission and the interpretation of the mission.

Using the anticipated location information the interpreter may preselect maps and prior coverage pertinent to the area. Information on time of mission and flight parameters may aid in selecting reference key information of the proper type. The stated mission purpose will enable the interpreter to concentrate his reference material in those areas of prime importance to the mission. The mission request (or the mission order generated from the mission request) will enable the interpreter to check his report against the requirements of the mission and if the mission has not fulfilled the purpose, to state why and recommend further coverage.

Flight Log and Pilot Debriefing. The Flight Log and pilot debriefing may be in the form of written or taped comments, flight map notations, or a checklist. The contents of the flight log (and/or pilot's debriefing) may present a wide variety of information useful to the interpreter during his review of the mission film. Such things as deviations from planned flight path or parameters, visual sighting of unusual activity, AA Fire, etc., may aid the interpreter by pointing out specific areas which should be investigated. The log or debriefing information should be made available to the interpreter prior to his review of the mission film. Prior coverage might also be reviewed on the basis of the pilot's information.

Information from the log or debriefing may also be used on the interpreter's report either in full or by reference. Positive or negative confirmation of pilot observations should be included in the interpreter's report or as a separate report, as the situation dicatates. The pilot's log may also be used as a back-up source of flight parameters in the event of malfunction or errors in the Code Matrix Block.

Code Matrix Block. The information contained in the code matrix block (CMB) if available is of primary importance to the interpreter both for flight parameter information and navigational data. From the coded data, input to computerized measuration and plotting operations is derived and rapid target location and measurement is possible. The parametric information contained in the CMB allows the interpreter to monitor the actual location, altitude, time and conditions under which a particular image or section of imagery was taken. Although the block is to be read by a special reader, in the event of reader problems it would appear that the information may be directly read by any interpreter with minimum of experience and practice.

Utilization Strategy

The purpose of the data base in operational interpretation is primarily to provide reference and key information. Contained on the chips composing the data base would be an extensive collection of representative imagery from which the user could select that which he felt would be most applicable to the particular mission at hand. Also in the data base would be chips containing map coverage of the area of operation and an index of reports and imagery of prior coverage. From this store the interpreter may draw material specific to his particular requirements for an individual mission.

The presentation of imagery of various target types at specified acquisition parameters, as given in the parameter accession position of the data base, adapts itself very readily for use in operational interpretation. By specifying the acquisition parameters, i.e., altitude, time of day, and detector cell, for a particular mission in an appropriate format, the interpreter would receive a listing of those chips containing imagery of all the target types in the data base acquired at the specified parameters. This request could subsequently be modified by the requestor to exclude all unwanted or inappropriate targets, specifying only those which would likely be located in the area of mission coverage. He may also then desire to obtain more imagery of particular targets in the target accession mode.

On the other hand, if the interpreter had made a tentative identification of a target on the mission imagery, he may desire to look at a number of examples of that target type for verification. Therefore, he could request chips from the Target Accession portion of the data base which would contain a number of examples of the particular target type. He may then desire to look at a particular target mode under various conditions in the parameter accession mode.

The detailed target information contained in the data base provides the interpreter with several types of very specific information concerning the characteristics, environment and signature(s) of any particular target type. In addition, imagery showing objects which are likely to be misidentified as targets are included.

Four factors would probably act as the most likely determinants of the specific key materials chosen by the interpreter for use in processing film from a mission. These are the mission request, the area over which the mission is flown, the targets shown on any prior coverage of the area, and the individual user's capabilities and confidence in detecting and identifying particular target types.

The first of these determining factors, the mission request, provides the user with the acquisition parameters of the mission, thus delineating the portions of the data base most relevant to his requirements. If for instance a mission was to be flown at 2000 feet at 0200 hours, a request for single examples of many targets could be made using the 2000 foot altitude and night as the time of day. In addition the mission request may, in many cases indicate specific targets that are to be located, as in the case of a mission requirement for route surveillance. In this instance vehicles are a primary target and would be requested from the data base.

The second factor, the area over which the mission is flown and the nature of the terrain and cultural features of that area has a great effect on the type of target lkely to be found. In a low land area, for instance, boats are probably targets while this generally is not the case in an upland region. Information such as this aids the user in excluding irrelevant target information from his selection and serves to keep his key chips to an easily managed number.

Target types shown on prior coverage of the area, the third determining item, should probably be included in the user's selection of key reference information. A review of the prior coverage also provides detailed knowledge of the area which allows the interpreter to refine further his selection of key material by including only relevant representative imagery and by choosing detailed information about likely targets.

The last determiner listed, the interpreter's capabilities and confidence in detecting and identifying particular target types, shapes the key reference material to be selected to the individual's unique requirements. The store of material contained on the data base chips, both representative imagery and detailed target information, gives the interpreter the capability of supplementing his knowledge and skill with reference information to fill any deficiencies in his knowledge. If for instance, the interpreter consistently has had difficulty in detecting and identifying emplacements, he may select a set of representative imagery of emplacements and the portion of the data base containing detailed information concerning the environment and signatures of emplacements.

EXAMPLE OF DATA BASE UTILIZATION

Upon receipt of a Mission Request requiring waterway surveillance at an altitude of 2000 feet from point AB XXXXXX to point AB YYYYYY at approximately 0100 hours, the interpreter would probably perform the following steps:

1. Enter the coordinates specified in the mission request into the computer and request map coverage at the appropriate scale. He receives on the CRT the accession number of the chip(s) containing the desired map(s).

2. Again enter the coordinates and request prior coverage of the area and receive a listing of prior missions flown over the area and storage index information for subsequent retrieval.

3. After studying the prior coverage and map coverage of the area and taking into consideration the nature of the mission request, the interpreter may then enter a request for key information which he feels would be useful for interpreting the anticipated imagery. For the present case he may request from the target accession data store night imagery of boats taken at 2000 feet and the misidentification section on boats from the Detailed Target Information file. In addition, depending on prior coverage and other collateral information, he may choose to select imagery of other targets such as vehicles or structures and material covering any subject in which he may feel deficient. In response to this request the computer provides on the CRT display a listing of chips which match the criteria specified in the interpreter's request against the data base index.

An alternative to the above procedure for selecting key information may be desired in some situations, such as when area coverage is specified in the Mission Request and little is known about possible targets in the area. Under these circumstances the interpreter may request the entire Parameter Accession imagery file for the flight parameters of the mission. In this case he receives a list of chips containing one representative image of each target type in the data base for the specified acquisition parameters.

4. At this point the interpreter should have the capability for generating a hard copy listing of the chips meeting his retrieval request, e.g., by means of an associated hard copy printout device.

5. With a hard copy of the chip numbers he wishes to use, the interpreter may then go to the TIIF's central chip storage file and retrieve the chips he wants to use.

6. The user would then load the chips he obtained from storage into the chip display device and keys their locations into the computer for future reference.

7. The interpreter would review the prior coverage and maps and at that point perhaps refine his selection of key material to conform more closely with the nature of targets likely to be imaged on the mission.

8. At this time, depending on the individual interpreter's experience level and work load, a review of the key material may be carried out.

9. Upon receipt of the mission imagery, the interpreter would begin the interpretation process. When a target is detected that the interpreter can not readily identify, he could call up the chip material containing representative imagery of what he suspects the target may be and base his decision on a comparison of the key material and the detected target. He would also be able to choose to view the misidentification material at this point.

10. After a target is detectd and identified, the interpreter would refer to the code matrix block on the imagery or the display of CMB information and perhaps his map coverage to obtain the coordinates of the target location for future reporting.

11. Continuing through the mission film, the interpreter would use the key material as needed, calling up chips on the viewing screen that he feels will aid him in his interpretation.

The data base is capable of providing the interpreter with a set of "custom" reference information, specific not only to the mission he is interpreting but also to his level of skill and his particular areas of interpretation difficulty. This method tends to minimize the bulk of information confronting the interpreter at any time and contributes to his overall efficiency.

TRAINING UTILIZATION

Initial Training. For initial training, data base material would generally be formally structured. One proposed method of structuring the data base information would provide three major phases of study: an introduction, the presentation of detailed target information, and complex target discrimination training. This would be accomplished by utilizing the reference information in a logical sequence designed to lead the subject through the available material from the general to the specific and the simple to the complex.

Listings of the portions of the data base required for such an instructional program would be available and would be obtained by students either in the form of hard copy or computer listings. To assemble a training segment, the chips specified on the listing would be drawn from the data base, inserted in the display device in the proper sequence, and chip locations keyed to the call-up device for viewing at the proper time. A typical presentation might be structured as was that used in the design experimentation to be reported below.

In conjunction with the instructional material, questions and answers concerning the chip material could be interspersed throughout the segments to monitor and reinforce the learning process. The questions may be interspersed through the data base material in a fashion somewhat similar to a programmed instruction sequence, although the material should not be considered as programmed instruction. The interpreter trainees may record their response to

the "question chips" and then compare these with the answers provided on an "answer chip". In this way the interpreter is provided feedback on the adequacy of his responses.

The physical requirements of including questions, and answers in this phase of instruction should pose no problems. It would simply require insertion of chips containing questions and answers into the data base and including them in their proper sequence in the listing of chips required for the particular sequence of instruction.

Following completion of a structured sequence of instruction, practical exercises could also be inserted into the training program. These exercises would consist of annotated imagery that the interpreter would be required to interpret and for which feedback would be given. Realism appears to be a prime factor in the development of practical exercises. In this sense, realism refers to the inclusion of all inputs and materials normally associated with operational interpretation, requiring the utilization of all the tools and skills demanded of an interpreter. After the interpreter has completed a practical exercise, he would be given feedback in the form of a "school solution". An exercise such as that just described would serve to integrate the previously acquired knowledge and would provide a measure of his ability to identify the target types studied.

Refresher Training. A proficiency test or feedback on the accuracy of prior reports would indicate areas of weakness where the interpreter needs practice. There are several methods by which the data base material could be used for this purpose. These methods can be classified into two main types of instruction; structured and unstructured. Under the unstructured condition the interpreter would assemble his own instructional material from the data base. Structured presentations would be composed of chips from the data base organized toward a specific instructional goal. These chips would consist of two types: the data base material previously discussed and (2) special instructional frames to guide the user through the material and to provide a series of questions and answers.

In an unstructured presentation the interpreter would be free to choose the chip material that he feels would be most beneficial. Under such a condition the interpreter simply "browses" through the representative imagery and/or detailed target information for the target or targets on which he is deficient.

The section of the data base containing many examples of one target provides a means of exposing the interpreter to representative imagery of targets on which he needs practice. By requesting many examples of one target type the interpreter obtains examples of the requested target type taken under all acquisition parameters. A review of this material reintroduces the interpreter to the signatures imaged by the target under all conditions of acquisition

The interpreter in need of refresher training also would have the detailed target information available to him. This portion of the data base would give a thorough description of the relevant parameters of the target in the form of text, photos, sketches, and imagery, and when the detailed target information on an individual target type is taken as a whole, the resulting sequence is not unlike that of a "text book" presentation.

Structured proficiency maintenance exercises might consist of selected portions of the data base material--both representative imagery and detailed target information, plus instructional material which would guide the user through the learning sequence.

It is not feasible at this time to present in great detail system procedures or a concept of operations. These details would be a function of the equipment selected and the programs and routines which would be ultimately developed. It is conceivable that equipment technology may advance sufficiently to warrant a modification of procedures as generalized in this report. A general design is presented here primarily to illustrate a concept of operations which could be employed and to illustrate these operations by way of diagrams and examples. The design offered could serve as a starting point for future designers.

Functional System Configuration. This section presents the general processing procedures required to support both training and operational interpretation. The system is envisoned as including a digital computer for the storage and retrieval of references (indexes), a film file (chips and roll), and hard copy (interpreters' reports). Each chip (slide) would contain one or more images (blocks) where an image may be a map, an interpretation key, imagery or other information. Each image (block) on a chip would be defined as a record with a corresponding index (digital record) stored in the computer. Computer records could also be generated for indexing film rolls and for hard copy reports.

Other equipment would include a CRT for use at an input/output terminal, film viewer for viewing chips, light table for roll film, a printer (desirable) for hard copy listing of computer output, files for chip storage, and file cabinets for hard copy reports. Other support equipment is likely to be integrated; however, the equipment listed above has been considered as the basic package for discussion in this report. Figure 9 illustrates this configuration.

The future system is expected to be highly interactive with direct interface between the interpreter and the data (both film and digital) by means of the information handling equipment. Using a CRT, the interpreter would query the digital computer for indexes to support data stored in film or hard copy form. The same CRT could be used for updating files and report generation.

In addition to the CRT for displaying accession numbers to film chips or other data, a keyboard -printer would appear desirable. It could operate in a shared mode with more than one station. The printer would enable an interpreter to get a hard copy of the listing displayed on the CRT. He could use this listing for selecting chips from the file or simply as a reference to a past request. Because of its slower speed, the printer is not recommended as a substitute for the CRT but as a device to augment the interpreter's interaction with the computer. Figure 7 therefore, shows the printer as an "optional" equipment.

Request Formats. The call-up, display, and completion of request formats should be highly interactive and a simple procedure from the user's standpoint. CRT terminal devices lend themselves to this form of interaction and can significantly conserve user's time by eliminating paper request forms and punched cards and by minimizing external look-up lists for codes, retrieval options, etc.

Requests would be entered against at least four different subfiles--Keys, Prior Cover, Interpreters' Reports, and Maps. Each of these subfiles could have its own, unique request format. The latter three request formats would be relatively straightforward with selected fields of information from these files displayed on the CRT. The interpreter could simply key in the appropriate map reference, e.g., coordinates, map number, or series. For prior cover, he could key in the geographical area of interest and date, and acquisition parameters. For references to specific reports, he could key in a specific date, mission/sorties or location.

The keys subfile is more detailed and would probably contain more records than the other files. In addition, the information in this file, although stored in a common format, is arranged and can be retrieved via several data organizations (parameter accession, target accession, detailed target information) as discussed elsewhere in this report.

Contained in the section on design experimentation that follows is an example of a retrieval procedure and possible request formats that would be used for accessing key reference information.

DESIGN EXPERIMENTATION

The previous sections of this report presented the results of a design analysis of the general reference information requirements of an advanced tactical image interpretation facility. The content and format of a proposed data base were specified along with an indexing strategy and retrieval methodology for such information. Several principles of use for such a data base were also defined.

This section describes the results of initial human factors experimentation designed to test aspects of the utilization of a key data base such as previously defined. For the purposes of this study an experimental data base of reference information for aid in the interpretation of infrared imagery was

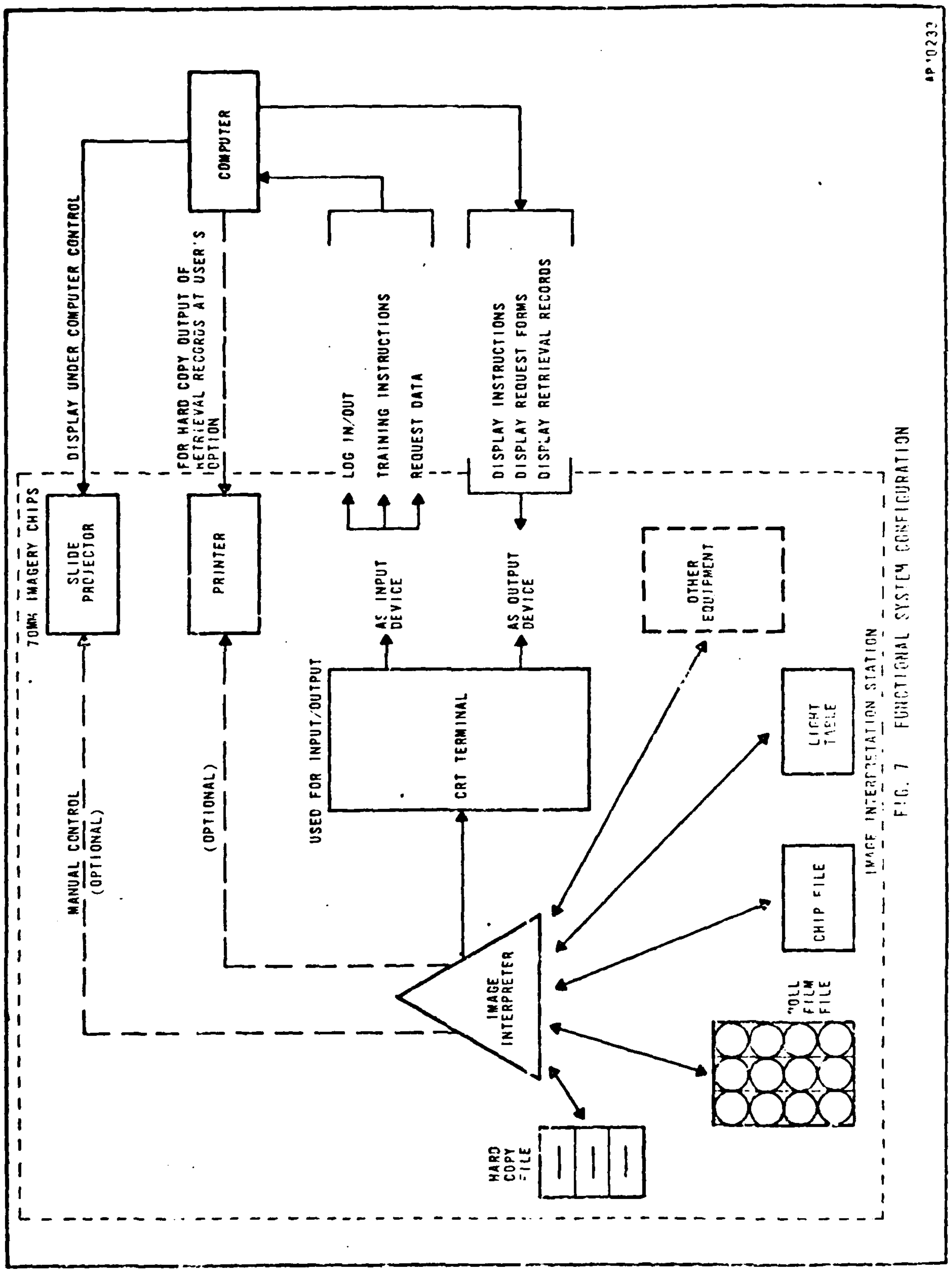

FIG. 7 FUNCTIONAL SYSTEM CONFIGURATION

constructed, resembling to a high degree that described previously. This data base contained the three basic organizations of information described in the previous analysis. These were (1) the Parameter Accession format, which was composed exclusively of representative imagery and showed the range of target types used in the study as they appear under a particular combination of acquisition conditions; (2) the Target Accession format, again composed of the same store or representative targets but organized to show each particular target as it appears under a variety of imagery acquisition conditions; and (3) Detailed Target Information, which described and illustrated the various targets in detail and provided information concerning their unique identification from IR imagery.

Indexing and retrieval software was developed to permit the use of the experimental data base with the equipment in the Information Systems Laboratory (ISL). This system, while differing in detail from that defined in the previous analysis, utilized the same types of equipment and was capable of performing the same functions as those envisioned for the advanced facility. The ISL equipment along with the experimental data base and necessary software permitted a simulation of the reference information storage and retrieval capabilities of an advanced facility.

The experimental data base, computer software developed for this study, and equipment within the ISL were used to conduct two different studies. One was designed to determine if structured exposure to data base material would increase interpreter proficienty in identifying targets from infrared imagery (Training study). The second experiment was designed to study the efficiency of such a data base as an aid to the interpreter during interpretation (Keys study).

The two experiments were carried out within the ISL using the same subjects. As will be described in more detail below, half of the subjects used were given training using the data base; half were given no training. Then all subjects participated in the Keys experiments.

The overall design for the two experiments is shown in the following schematic and is presented for ease in following the ensuing discussion.

TRAINING STUDY	PARAMETER ACCESSION KEY ONLY	TARGET ACCESSION KEY ONLY	BOTH KEYS	NO KEY
TRAINING →	N=8	N=8	N=8	N=8
NO TRAINING →	N=8	N=8	N=8	N=8

Method

<u>Experimental Data Base Development</u>. The first step in developing the experimental data base was to specify the set of representative imagery from which the Parameter Accession and Target Accession information categories would be organized. Infrared imagery was chosen as the sensor type for which the data base would be developed. Certain relevant parameters were selected around which to organize the data base with the exact sets of variations within each parameter being dictated by the availability of suitable imagery. Table 2 shows the target categories and subcategories used in Table 3 shows the acquisiton conditions selected for use in the study. It was felt that these dimensions were realistic in terms of their importance to the interpretation of infrared imagery and further were realistic in terms of the availability of imagery.

TABLE 2 TARGET CATEGORIES AND SUBCATEGORIES CONTAINED IN THE EXPERIMENTAL DATA BASE

AIRCRAFT (A/C)	LIGHT OBSERVATION	FIRE	
	HELICOPTERS	PERSONNEL	
BOATS	BARGE	STRUCTURES	BRIDGE
	SAMPAN		POL TANKS
	SHIPS (I.E., OCEAN-GOING)		TENTS
EMPLACEMENTS	ARTILLERY		HUTS
	BUNKER	VEHICLES	HEAVY MOTORIZED
	LIGHT WEAPON		LIGHT MOTORIZED
	MISSILE		INDIGENOUS
	TRENCH		AP 10241

TABLE 3 ACQUISITION PARAMETERS USED FOR SELECTING IMAGERY FOR THE EXPERIMENTAL DATA BASE

ALTITUDE	TIME OF ACQUISITION	DETECTION CELL
500 FEET	DAY	SHORT WAVELENGTH
1000 FEET	EVENING	LONG WAVELENGTH
2000 FEET	NIGHT	AP 10 242

For the Parameter Accession portion of the data base two slides were required to show the complete list of 19 targets (at the subcategory level) under each individual set of acquisition parameters. The first slide in each set contained images of the different targets in the vehicles, structures, and boats target categories; the second slide showed fires, aircraft, emplacements and personnel. An example of the first slide in each set is shown in Figure 8. The eighteen combinations of acquisition parameters resulted in a total of thirty-six slides.

For the Target Accession portion of the data base each target subcategory was shown under the eighteen different combinations of acquisition conditions. Two slides were used to show these eighteen images; the first showed six images taken at 500 feet altitude (for all combinations of time and detector type); the second slide (Figure 9) contained twelve images showing the target at 1000 and 2000 feet altitudes. As there were nineteen target subcategories used in the study, a total of thirty-eight Target Accession slides were required in the data base.

A set of Detailed Target Information (DTI) slides was developed for each of the target categories listed in Table 2. The information categories and subcategories developed for inclusion in the experimental data base were:

1. Target Description

   a. Target Characteristics: the physical characteristics of the target in terms of size, shape and material composition.

   b. Basic Signature: the spatial and thermal imaging qualities of the target as they appear on IR imagery.

   c. Cues to Identification: locational and associative characteristics and activities relevant to the identification of the target.

2. Enemy Employment

   a. Target Environment: the location in which the target is likely to be situated.

   b. Counter-Reconnaissance Measures: steps taken to avoid detection by airborne sensors.

   c. Target Pattern: the pattern in which multiple occurrences of the target may be found.

   d. Complex Target Array: multiple target combinations in which the subject target might be located.

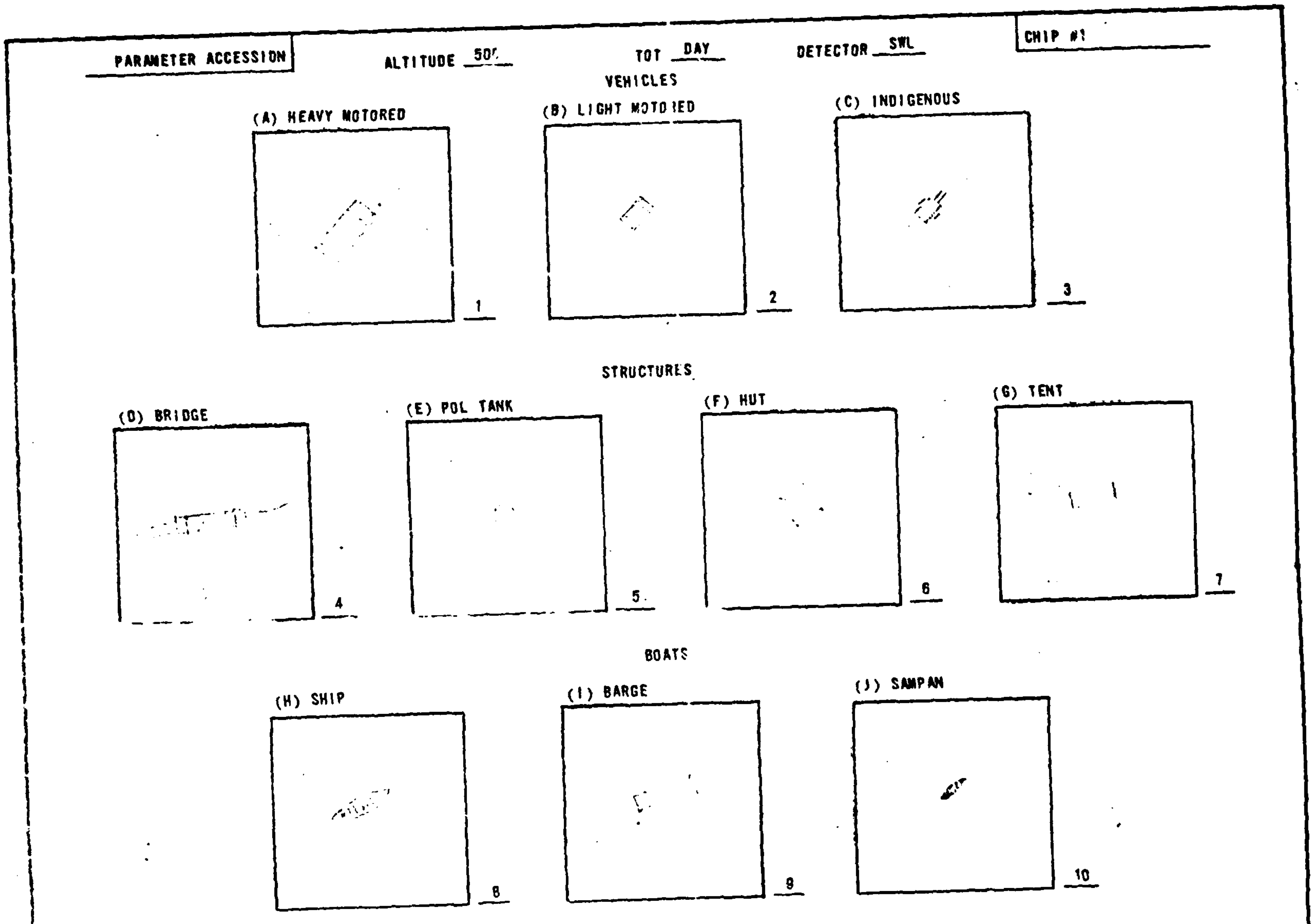

FIG. 8 EXAMPLE OF PARAMETER ACCESSION SLIDE ORGANIZATION

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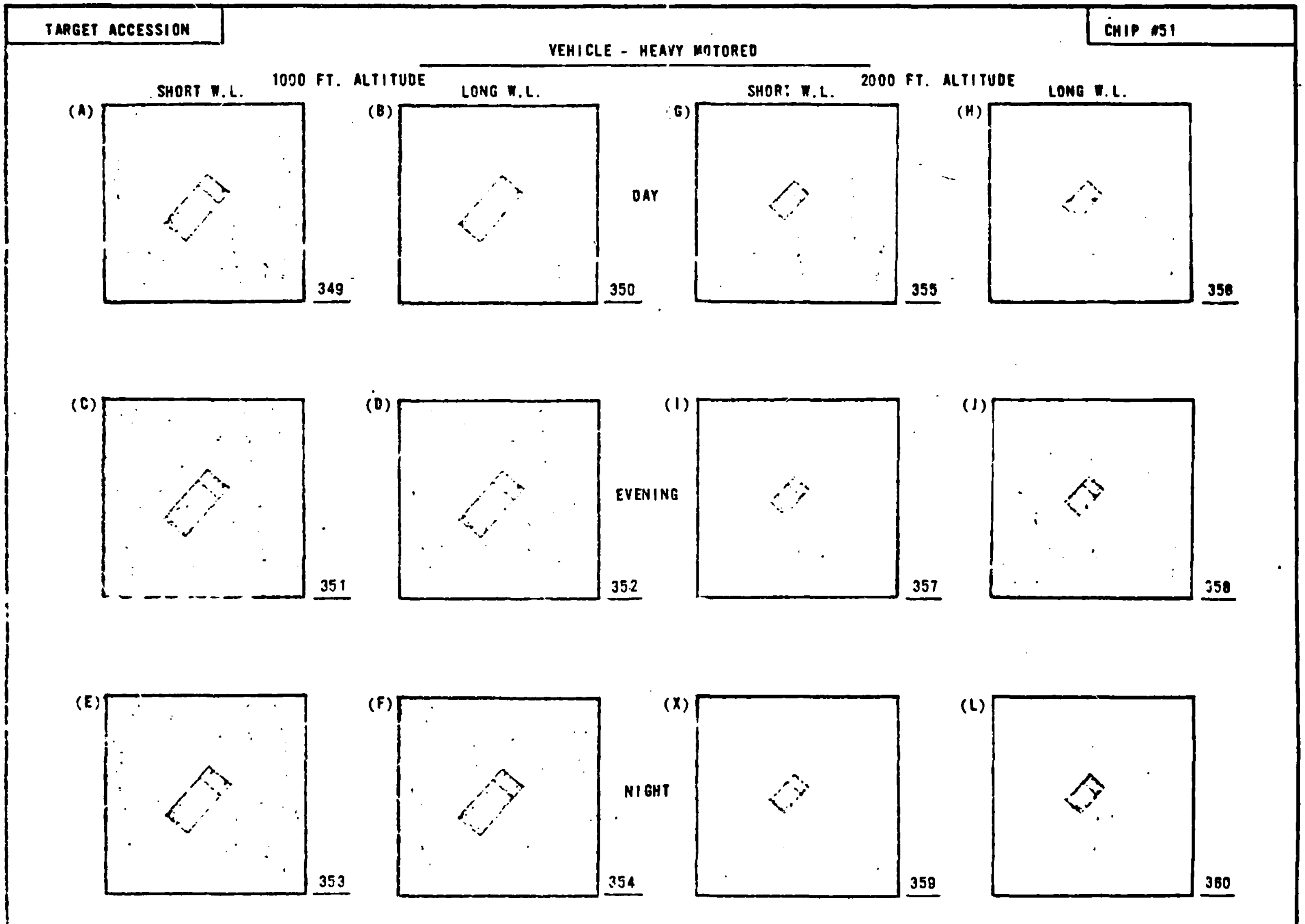

FIG. 9 EXAMPLE OF TARGET ACCESSION SLIDE ORGANIZATION

AP 10227

3. Misidentification: this section was primarily composed of imagery with supporting text to depict and describe other targets and natural objects commonly misidentified as the subject target.

Figure 10 presents an example of a slide from the Detailed Target Information portion of the data base. The Detailed Target Information portion of the data base was composed of forty-four slides.

Slide Format and Presentation. The data base was contained on 3 1/2 x 4 inch slides and was presented in a negative format (i.e., the images presented were negatives and all lettering appeared as white on black)[3]. Imagery for the data base was acquired from exercise materials and operational imagery. Of the 342 images required to complete all combinations of targets and acquisition parameters, 308 (87 percent) were obtained for the study.

Contact prints of the selected images were made from image transparencies and cut to a 1-1/4 X 1-1/4 inch size. This size was large enough to show significant features associated with the targets at all altitudes, but still small enough to allow a number of images to be placed on each slide. These prints were placed on layout boards. Textual material was typed on a standard typewriter using elite type, then reduced to 80 percent of the original size using a photocopying process. This reduction in type size allowed significantly more textual information to be presented on each slide while still allowing sufficient letter size for the material to be easily read when projected. The layouts were then photographed using a 2.5X reduction and the negatives mounted as 3-1/4 X 4 inch slides. When displayed, the slides were projected at 3.2 times original size, with overall dimensions of 25" X 32.5".

Laboratory Equipment. Experimentation was conducted in ARI's Information Systems Laboratory (ISL). A schematic representation of the ISL equipment as configured for the study is shown in Figure 11.

Data base slides were presented on a rear projection screen using a Telepro RA-60, random access slide projector[4]. For the training study the projectors were controlled manually by the subjects. Slides were placed in the desired order for instruction by the experimenter and the subject had only to depress an "Advance" button to view the next slide in the series. In the Keys study the subject entered his request for listings meeting his retrieval entries and for slides through the CRT keyboard; subsequently, slides requested were presented

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3 A few of the images were positive transparencies and were labeled as such.

4 Commercial designations are given only in the interest of precision in reporting and do not constitute endorsement by the Army, or by the research organization involved.

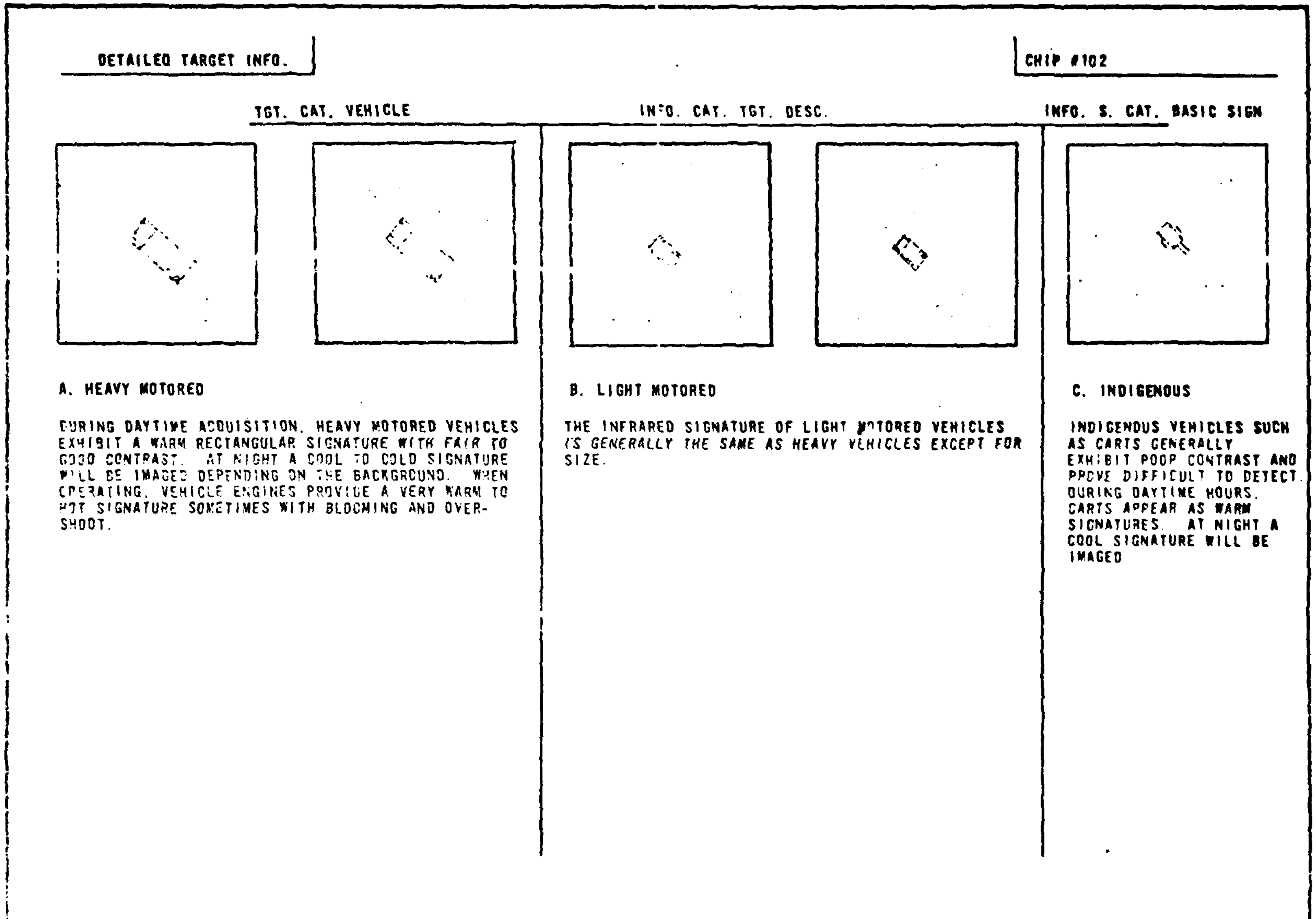

FIG. 10 EXAMPLE OF DETAILED TARGET INFORMATION SLIDE ORGANIZATION

AP10279

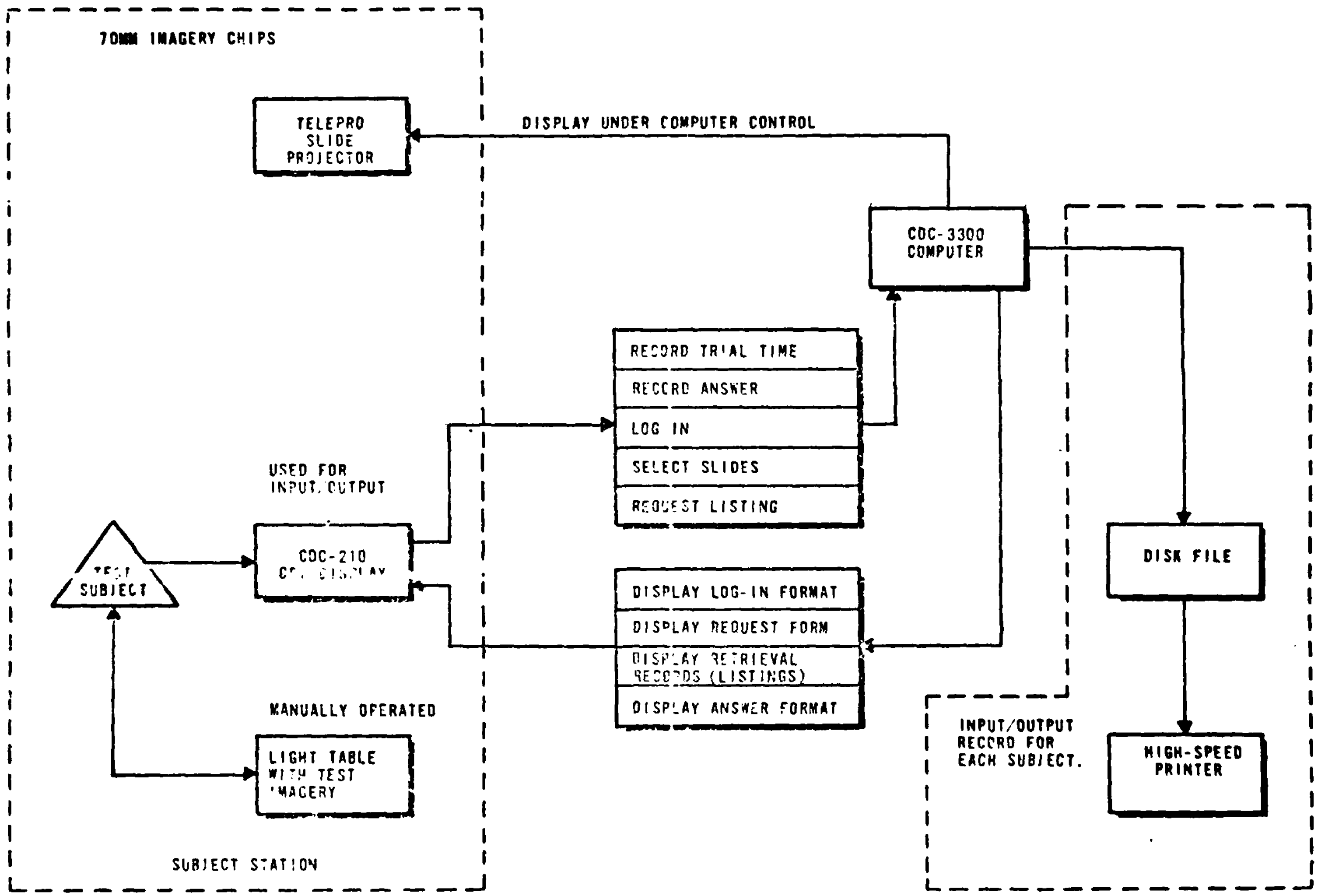

FIG. 11 SYSTEM CONFIGURATION FOR KEYS EXPERIMENT

AP3351

by computer control of the projector. All interaction between the subject and the computer was accomplished on this CRT keyboard (a CDC Model 210). Briefly, the device consisted of a typewriter on which subject entered his inputs and a CRT display on which both input and output messages were displayed. The input and output functions served by this display are shown in Figure 11.

A CDC 3300 computer provided the information processing capability for the Keys experiment. The computer along with associated software served two basic functions: (1) it processed subject requests for both information concerning the data base slides and controlled the presentation of the slides themselves, and (2) it recorded relevant experimental information such as time and subject responses for later retrieval and analysis.

The remaining piece of equipment was a standard manually operated light table on which the subject viewed the rolls of test imagery.

For the training study four subject stations were configured to provide instruction to four subjects during each session. The equipment used by each subject consisted of a random access slide projector, an associated control device for advancing to the next slide, and the rear projection screen, along with the light table for viewing test imagery. The 118 data base slides were arranged in the proper sequence for instruction; the subject was merely required to advance from one slide to the next.

The Keys study utilized all of the equipment previously described and shown in Figure 11. Four subjects were tested during each session, one from each of the four experimental key conditions. Two of these conditions required the use of one slide projector each, one condition used two projectors simultaneously and the fourth, the No Key condition, did not require a projector.

Test Imagery. Three test rolls were developed for use in the two experiments. Each test roll consisted of thirty frames of infrared imagery, each frame containing one annotated target. The test frames were in the form of negative transparencies mounted on 5-inch roll film which was viewed on a standard light table. The target types represented in the test rolls were the same as those in the data base (plus some annotated nontargets used as distractors), and the acquisition parameters for these images were also limited to those combinations covered in the data base. The acquisition conditions (altitude, time of take and detector cell) for each image were provided adjacent to each test frame.

The first roll was administered to all subjects for the purpose of obtaining a measure of initial performance level. The second roll was administered immediately following the course of instruction for those subjects receiving training to obtain a measure of the effect of the instruction on the subject and was also administered to the control group who had not received the course of instruction. The third roll was used in the Keys study to assess the effectiveness of the various parts of the data base as keys during the actual course of interpretation.

The number of target subcategories contained in each of the test rolls is shown in Table 4. For the most part each target subcategory appeared twice in each test roll. For each test roll there was no identification to be made (including "non-targets"). The limit of thirty targets per roll, however, required exceptions and was achieved by limiting the occurrence of those targets judged to be either the easiest or the most difficult. Detailed descriptions of the three test rolls are given in Appendix B.

Subjects. A total of sixty-four image interpreters served as subjects in the study. Sixty of the subjects were recent graduates of the Image Interpretation (Enlisted) Course of the U. S. Army Intelligence School, Fort Holabird, Maryland. The remaining four subjects had in addition completed the Image Interpretation Skill Development Course at Fort Holabird.

All subjects participated in both experiments. Half of the subjects received training, half did not. Upon completion of the first experiment, subjects were assigned to experimental conditions for the second study.

Subject Assignment for both studies was made to balance the experimental groups on General Technical (GT) Aptitude Area Score (from the Army Classification Battery). The distribution of subjects by GT score for the two studies were:

GT Score	#Subjects/Cell (Training Study)	# Subjects/Cell (Keys Study)
140 +	4	1
130-139	12	3
120-129	12	3
110-119	4	1
	32	8

The Group averages for the two conditions in the Training Study were:

	Average GT Score
Training	128.78
No Training	128.88

The group averages for the eight groups of eight subjects each for the Keys study were:

Training	Average GT Score	No Training	Average GT Score
Parameters Accession Key Only	128.50	Parameter Accession Key Only	128.88
Target Accession Key Only	128.75	Target Accession Key Only	129.25
Both Keys	128.88	Both Keys	128.63
No Key	129.00	No Key	128.75

TABLE 4 TARGET MAKEUP OF THE THREE ROLLS OF TEST IMAGERY			
			AP10236
TARGET CATEGORY SUBCATEGORY	NUMBER OF OCCURRENCES		
	PRE-TEST	POST-TEST	KEYS TEST
VEHICLES			
HEAVY MOTORED	2	2	2
LIGHT MOTORED	2	2	2
INDIGENOUS	0	0	0
STRUCTURES			
BRIDGE	1	2	2
POL TANK	2	2	2
HUT	2	2	1
TENT	1	1	2
BOATS			
SHIP	1	2	1
BARGE	2	1	2
SAMPAN	2	2	2
FIRE	2	3	1
AIRCRAFT			
LIGHT OBSERVATION	1	1	1
HELICOPTER	1	2	0
EMPLACEMENTS			
MISSILE	1	0	1
ARTILLERY	2	2	2
TRENCH	1	2	2
BUNKER	2	1	2
LIGHT WEAPON	1	0	1
PERSONNEL	2	1	2
NON-TARGET (DISTRACTORS)	2	2	2

General Experimental Procedures. For the training study the sixty-four subjects were divided into two groups of thirty-two each, matched on GT score, as previously described.

The subjects were given a brief description of the nature of the study. They were informed that the first test roll was to be used to obtain a measure of their capabilities in IR interpretation. A description of the contents of the test roll was provided and the subjects were reminded that the images they would be looking at would be negative transparencies. The subjects were informed that there would be no time limit and that they should identify the test targets as accurately as possible. When interpreting all test tolls, interpreters used standard manual light tables and had available 2.5X and 8X tube magnifiers. Initially, each of the 64 subjects were given the pre-test. The Training group was then given approximately 1-1/2 hours of instruction using the data base in the prescribed sequence (as described in the following section). The other group then participated in other activities not related to the study. For display of the key materials for training, the rear projection system described was used. Both the trained and untrained groups were administered the second test roll (to determine the benefits derived from the instruction given).

The sixty-four subjects were then assigned to the appropriate experimental conditions for the Keys study. They were instructed to use the key material available to them (for three of the four key groups) to aid them in the identification of targets on the third test roll. The forty-eight subjects having keys available as an interpretation aid were told that for each identification made they were to indicate which "block" of numbered imagery on a slide they used in making their final identification. (This requirement was imposed to insure that the interpreters having keys available to them would use them. Without this insurance, interpreters could have elected not to use the material available to them and, thus, prevented a comparison of the relative value of the different key types).

Training Study

Earlier sections of this report described the potential utilization of the key reference material data base within the advanced TIIF for on-the-job training. As indicated earlier, a study was designed to see if structured exposure to data base material would increase interpreter proficiency in identifying targets from infrared imagery.

For this purpose a program of instruction was structured from the experimental key data base, composed of materials from the Parameter Accession, Target Accession, and Detailed Target Information materials discussed earlier. The organization of the available experimental material was developed to proceed generally from more easily interpreted targets to more difficult ones and within each target category to begin with the simpler aspects of individual target interpretation and proceed to the more complex. The organization selected was only one of a possible number that could have been selected; however, it was based upon the best judgments of an experienced IR interpreter and human factors research personnel familiar with infrared imagery interpretation and the development of instructional materials for interpreter training.

A diagram of the instructional sequence selected is shown in Figure 12. The presentation was structured as follows:

1. Chips from the Target Accession section showing Vehicles, all at an altitude of 500 feet but under the range of three times of acquisition and two detectors served as an introduction to this target type and showed changing appearances under differing conditions.

2. The Target Description and Enemy Employment sections for each Vehicle subcategory were then shown to provide instruction in the basic details of the target characteristics, signatures, and environment.

3. More difficult discriminations were then stressed with the presentation of the Target Accession chips showing the Vehicle target subcategory at 1000 and 2000 feet, again combined with each of the three times of day and two detectors.

4. Steps one, two and three were then repeated for Structures, Boats, Fires, Aircraft, Emplacements, and Personnel in that order.

5. The misidentification section of the Detailed Target Information was then shown for each target category.

6. The last step in the instructional sequence showed images of the range of targets presented under a common set of acquisition parameters (from the Parameter Accession data base set). The purpose of this was to enhance the subject's discrimination of the various target types under comparable conditions by the simultaneous presentation of targets together. The complete set of Parameter Accession slides was shown, beginning with those showing targets at 500 feet and proceeding to 1000, then 2000 feet.

Through exposure to the instructional sequence, subjects were exposed to all slides in both the Parameter Accession and Target Accession organizations. For this study, the interest was to determine change in performance due to exposure to the training program developed from the experimental data base materials. Thirty-two of the sixty-four subjects were exposed to the training sequence; the remaining 32 subjects served as a control group. All sixty-four subjects were administered the first roll of test imagery (pre-test) and told to identify the thirty targets contained on the roll. Following administration of the instructional sequence, the thirty-two subjects in the Training group were administered the second test roll (post-test). The No Training group (control) was administered the second roll immediately prior to their participation in the Keys study.

A one way analysis of covariance was carried out, using pre-test performance as a control variable to adjust for initial performance level. The dependent variables of interest in the analysis of post-test performance were: number of correct identifications, time to complete the post-test roll, log time to complete post-test roll (to compensate for possible skewness of the data) and identifiction efficiency (defined as the number of correct identifications divided by the time required to complete the test roll). Correct identification and efficiency scores were analyzed at two levels. The first

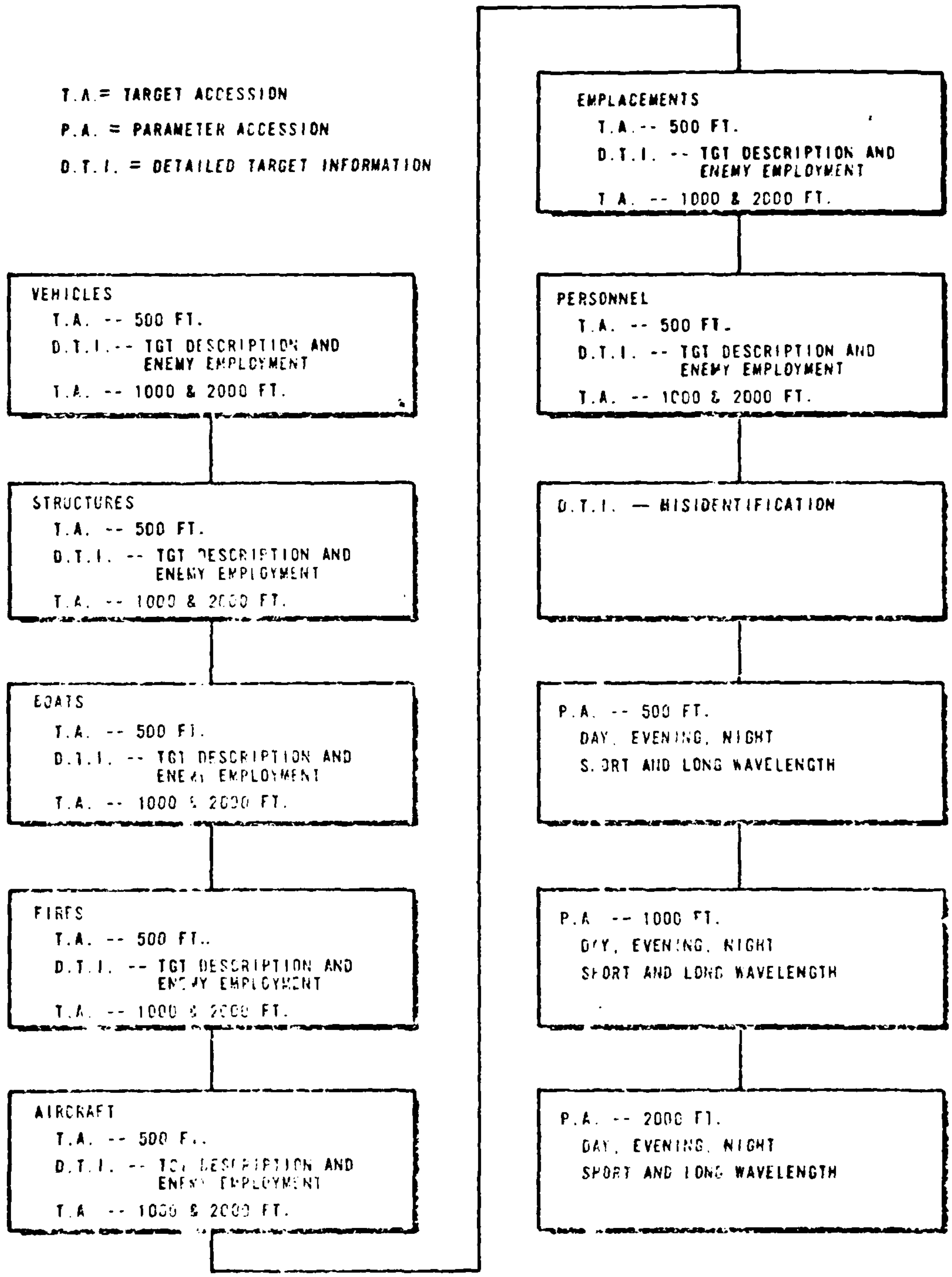

FIG. 12 SCHEMATIC OF INSTRUCTIONAL SEQUENCE

level was at the target category level (e.g., vehicles), which would represent a measure of the subject's ability to identify targets as to the general class to which they belong. The second level of analysis looked at interpreter performance at the target subcategory level (e.g., within the category "vehicles" performance was analyzed in terms of the more precise identification of targets as light motored, heavy motored, or indigenous vehicles).

Keys Study

Variables. The primary purpose of this study was to evaluate the relative effectiveness of different portions or combinations of the experimental data base as interpreter aids to identification. Four key conditions were studied: Parameter Accession slides only, Target Accession slides only, both Parameter Accession and Target Accession slides, and a "No Key" condition, for control purposes. The condition where the subjects had access to both organizations was included to determine if access to both types of information would permit better performance than would access to only one type of organization. The second independent variable of interest was the effect of previous training on identification performance during interpretation (under one of the key material utilization conditions). Also of interest was the possible interaction between prior training and the different key conditions.

Figure 13 repeats a portion of the overall design shown earlier in the Introduction and represents the experimental design for the Keys Study.

	PARAMETER ACCESSION ONLY	TARGET ACCESSION ONLY	BOTH PARAMETER & TARGET ACCESSION	NO KEY
TRAINING	N=8	N=8	N=8	N=8
NO TRAINING	N=8	N=8	N=8	N=8

FIG. 13 EXPERIMENTAL DESIGN FOR KEYS STUDY

AP 10238

The dependent variables used for studying interpreter performance based upon interpretation of the third test roll were: number of correct identifications (out of thirty), time to complete the test roll, log time to complete the test roll, and identification efficiency (again defined as number of correct identifications divided by the time to complete the test roll). The identification and efficiency scores were again analyzed at two levels of identification--at both the target category and target subcategory levels.

Subjects. As previously indicated, the thirty-two subjects who had received the instructional segment were assigned to one of the four key utilization conditions in a manner that permitted four groups of eight men each, matched on GT score. Similarly, the thirty-two subjects who were not provided training were assigned to key utilization conditions to provide groups matched on GT score.

Test Imagery and Interpretation Task. The third roll of test imagery was interpreted by all sixty-four subjects, who were required to identify as accurately as possible the targets contained on the test roll. To aid them in their examination they were provided with 2.5X and 8X tube magnifiers. Six of the groups had some portion of the data base to aid them in their identification; two groups (the Training and No Training groups assigned to the "No Key" condition) did not have access to the data base.

Procedures. Subjects assigned to the "No Key" condition were simply required to identify the targets on the test roll. However, subjects assigned to one of the conditions requiring interaction with the data base were given a detailed description of the portion or portions of the data base available to them. A more complete description was provided to those subjects who had not had occasion to become familiar with the data base during training (i.e., the thirty-two subjects in the No Training group). Subjects interacting with the data base, using the ISL configuration shown earlier in Figure 11, were given a detailed explanation of the procedure required for requesting a listing of slides meeting their retrieval requirements or for selecting a slide stored in the random access slide projector. The procedures to be followed by the subjects interacting with the data base are delineated below and shown in Figure 14.

a. After a subject "logged in" (and was assigned a subject number for control purposes), the CRT presented him with "Ready" display which stated: Turn to Target, When Ready Press Send Key.

b. The subject was then presented a Request Format on the CRT, shown in Figure 15. Using this Request Format, the subject selected the desired target categories and subcategories, as well as the acquisition parameters desired by positioning an X in the appropriate locations. Those subjects having access to both portions of the data base were required to specify which set they wished to use on each request ("A" for Parameter Accession, "B" for Target Accession); subjects having access to only a single organization of the data base did not have to so specify. The Request Format consisted of two parts. The first was used to indicate the target category or target subcategory desired, the second to select the desired acquisition parameters. In making his selection the

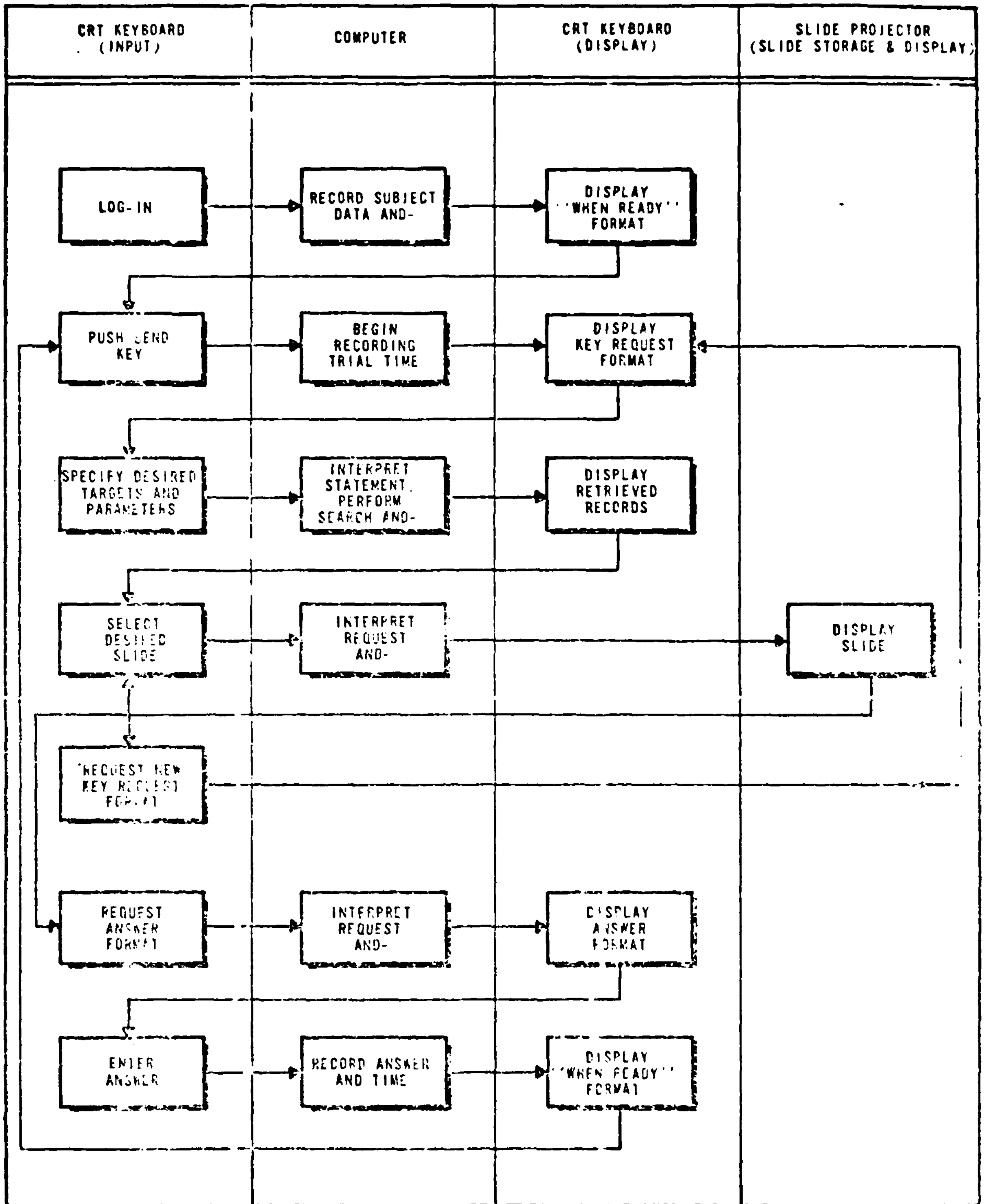

FIG. 14 GENERAL FLOW CHART OF PROCEDURES IN KEYS UTILIZATION STUDY

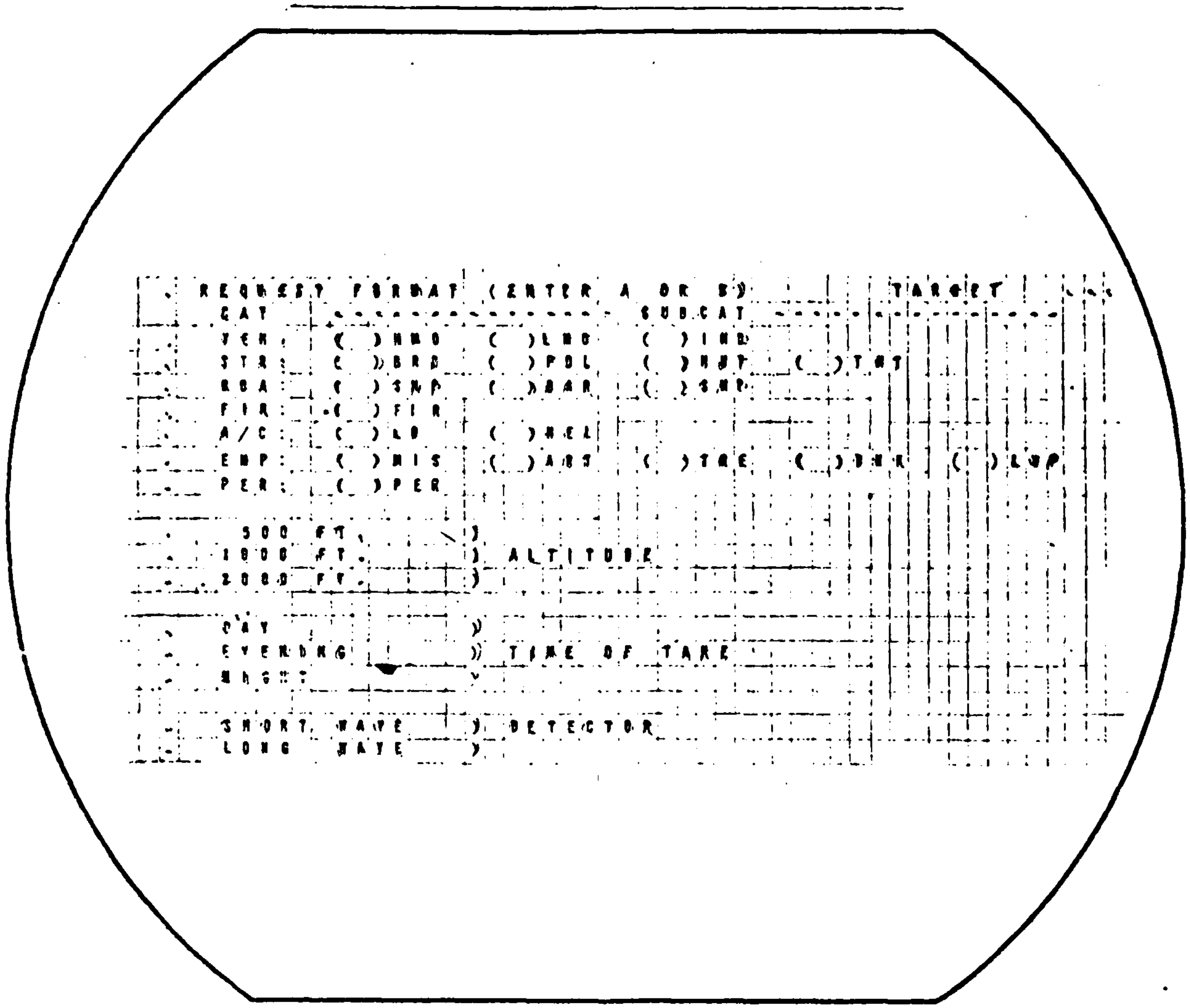

FIG 15 SAMPLE REQUEST FORMAT

subject was required to select a minimum of one target subcategory, one altitude, one time of day and one detector. (The maximum request possible was a request for the complete set of key materials).

c. After the subject completed filling in his request using the CRT keyboard and pressed the SEND key on the keyboard, a list of slides meeting his retrieval criteria was displayed to him as shown in Figure 16.

d. The subject then indicatd the slide he desired to view by entering an X next to the appropriate item on the list of slides presented on the CRT.

e. The slide was then accessed under computer control and displayed to him on the rear projection screen.

f. At this point the subject had available three options. He could:

(1) Call up the Request Format again by requesting it in the appropriate space on the output format and repeating Step b and following the subsequent steps to look at other slides.

(2) Decide to select another slide from the list displayed on the CRT by repeating step d.

(3) Call up the Answer Format, shown in Figure 17, and terminate the trial by entering his answer.

As shown, the Answer Format provided space for the subject to enter the category and subcategory for his identification. The subject was also required to enter the number of the block of imagery (found adjacent to each image) that he used in making his identification.

g. When the subject had completed the Answer Format, he pressed the SEND key, which transmitted it to the computer, terminating the trial. His answer, the time taken for the trial and the image block used in the identification were recorded on disc storage.

h. The CRT presented instructions to proceed to the next target and the subject then repeated steps b through g for the remaining twenty-nine images on the test roll.

Results

As the same subjects and identical performance measures were involved in the two studies conducted, a brief overview of the analyses carried out will help in interpreting the results to be presented. A total of 64 subjects were used all of whom participated in both experiments. Thirty-two were exposed to the instructional segment used in the training study; thirty-two comprised a control group and were given no training. Upon completion of the training study, the thirty-two subjects receiving training were assigned in matched groups to one of the four key conditions; the thirty-two subjects not receiving training were similarly assigned to the four conditions. Thus, there were eight subjects assigned to each of the eight cells in the 2 X 4 factorial design for the Keys study.

NEXT: . PAGE NUMBER. , RE - NEW REQUEST, AN - ANSWER

CHIP	FMT	TARGET CAT	TARGET SUBCAT	ALT	TOT	DEV
051F	B	VEH	MNTR	500	NIGHT	LWL
[illegible]	B	VEH	MNTR	1000	NIGHT	LWL
080F	B	STRUCT	HUT	500	NIGHT	LWL
081F	B	STRUCT	HUT	1000	NIGHT	LWL
082F	B	EMPLC.	BUNK	500	NIGHT	LWL
083F	B	EMPLC.	BUNK	1000	NIGHT	LWL

PAGE 1 OF 1

TARGET 1

FIG 16 SAMPLE OUTPUT FORMAT CONTAINING COMPUTER GENERATED SLIDE LIST

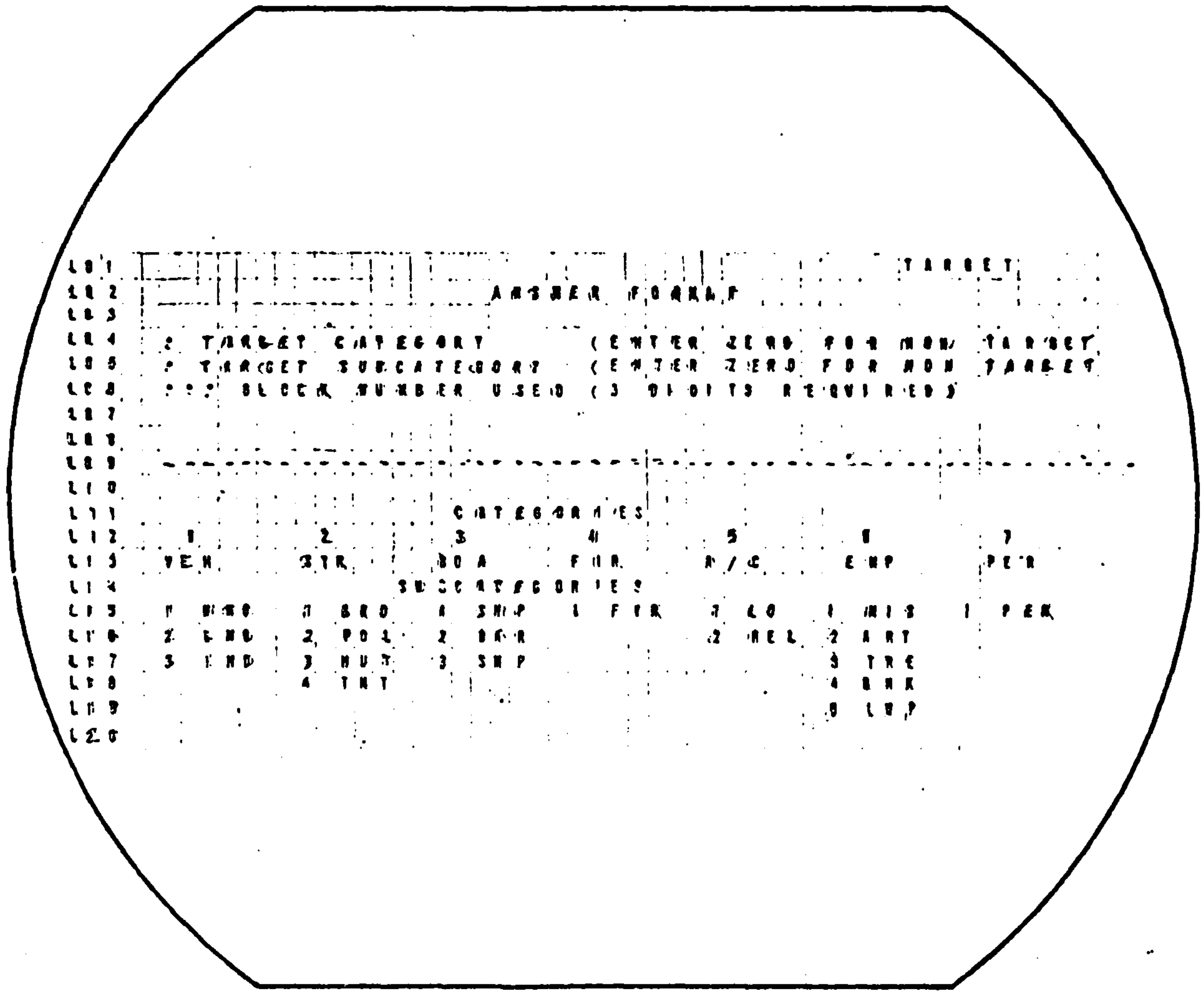

FIG. 17 SAMPLE ANSWER FORMAT

The same six dependent measures of performance were used for both studies. As the performance measure in both studies involved identifying thirty targets on a roll of IR test imagery, similar measures could be used. The six measures were:

1. Number of correct identifications (at the level of target category).

2. Number of correct identifications (at the level of target subcategory).

3. Time in minutes to complete the test roll.

4. Log time to complete the test roll.

5. Identification Efficiency (at level of target category): # correct at category level/time to complete test roll.

6. Identification Efficiency (at level of target subcategory): # correct at subcategory level/time to complete test roll.

For both experiments analyses of variance were initially performed. Correlation between pre-test score and post-test score for the six variables were carried out for the Training study. As will be seen, for the Training study, the magnitude of the obtained correlations were sufficiently large to dictate an analysis of covariance to adjust for the influence of initial interpretation ability on post-test performance for the different experimental groups. Similarly, for the Keys study the correlations between pre-test performance and interpretation performance on the third test roll were calculated. Again, the magnitude of the obtained correlations justified the running of analyses of covariance to adjust for initial performance differences among groups.

Training Study. Table 5 presents the mean pre-test score for the Training and No Training (Control) groups.

Table 6 shows the actual mean post-test performance for the two training groups, the correlation between pre-test and post-test scores for each measure, the adjusted means (from the analyses of covariance), and the significance levels for differences in performance for the two groups for the six dependent variables. (Analysis of covariance tables may be found in Appendix B).

The results shown in Table 6 indicate that interpreters who were provided training identified correctly significantly more targets at the level of target category then the control group. No significant differences were found for any of the other measures. Thus, it may be seen that the training provided increased the subject interpreter's ability to identify targets correctly at the more gross level of identification. While, for instance, the subjects provided training were not able to say any more precisely whether a target was a light motorized or a heavy motorized vehicle, they were better able to identify it as a vehicle. Infrared imagery does not have the resolution of a good photographic sensor and in many images pertinent details may be missing for distinguishing among targets at the subcategory level. The results d_o indicate, however, that interpreters who were provided training by means of a structured presentation of the experimental key data base were able to identify targets on IR imagery better than untrained subjects.

TABLE 5 MEAN PRE-TEST PERFORMANCE BY TRAINING GROUP FOR THE SIX DEPENDENT MEASURES AP10248	TRAINING	NO TRAINING
NUMBER CORRECT (TARGET CATEGORY)	19.15	18.50
NUMBER CORRECT (TARGET SUBCATEGORY)	14.84	13.66
TIME (IN MINUTES) TO COMPLETE TEST ROLL	29.75	25.59
LOG TIME TO COMPLETE TEST ROLL	1.44	1.38
IDENTIFICATION EFFICIENCY (TARGET CATEGORY)	.77	.82
IDENTIFICATION EFFICIENCY (TARGET SUBCATEGORY)	.58	.61

TABLE 6 SUMMARY TABLE OF ACTUAL AND ADJUSTED POST-TEST PERFORMANCE MEANS

AP10243

	ACTUAL		PRE & POST TEST SCORE CORREL.	ADJUSTED		SIG LVL
	TRAINING	NO TRAINING		TRAINING	NO TRAINING	
NUMBER CORRECT (TARGET CATEGORY)	22.22	20.69	.39	22.05	20.66	.05
NUMBER CORRECT (TARGET SUBCATEGORY)	17.28	16.06	.44	17.06	16.28	NS
TIME (IN MINUTES) TO COMPLETE TEST ROLL	19.63	18.47	.44	19.62	18.47	NS
LOG TIME TO COMPLETE TEST ROLL	1.27	1.25	.45	1.26	1.26	NS
IDENTIFICATION EFFICIENCY (TARGET CATEGORY)	1.23	1.20	.60	1.25	1.19	NS
IDENTIFICATION EFFICIENCY (TARGET SUBCATEGORY)	.86	.84	.69	.87	.93	NS

Keys Study. The pre-test mean scores for the two training conditions and the four key conditions are summarized in Table 7.

TABLE 7 MEAN PRE-TEST PERFORMANCE FOR SUBJECTS SUBSEQUENTLY ASSIGNED TO TRAINING AND KEY CONDITIONS

	TRNG COND		KEY CONDITIONS			
	TRNG (N=32)	NO TRNG (N=32)	PA* (N=16)	TA (N=16)	BOTH (N=16)	NO KEY (N=16)
NUMBER CORRECT (TARGET CATEGORY)	19.53	18.50	19.43	19.25	18.44	18.94
NUMBER CORRECT (TARGET SUBCATEGORY)	14.84	13.66	14.63	14.56	13.14	13.69
TIME (IN MINUTES) TO COMPLETE TEST ROLL	29.75	25.59	24.88	28.56	28.44	28.81
LOG TIME TO COMPLETE TEST ROLL	1.44	1.38	1.36	1.43	1.42	1.44
IDENTIFICATION EFFICIENCY (TARGET CATEGORY)	.77	.82	.90	.78	.75	.74
IDENTIFICATION EFFICIENCY (TARGET SUBCATEGORY)	.58	.61	.68	.61	.57	.52

*PA - PARAMETER ACCESSION ONLY
TA - TARGET ACCESSION ONLY
BOTH - BOTH PARAMETER ACCESSION AND TARGET ACCESSION

AP 10237

Table 8 shows the actual and adjusted mean performance values obtained when interpreters were required to interpret the third test roll under one of the key utilization conditions. The next table (Table 9) summarizes the results of the analysis of covariance (Detailed Analysis of covariance tables can be found in Appendix B).

From Table 9 it may be seen that on the basis of the covariance analyses, which were dictated by the correlations between pre-test performance and that on the Key Test roll that a significant difference (at the .05 level) between the group that had had training and the group that had had no training was obtained for number of correct identifications at the target category level. The Training and No Training groups did not differ significantly on any of the other five performance measures. The obtained significant difference in performance for target identification at the target category level supports

TABLE 8 ACTUAL AND ADJUSTED MEAN PERFORMANCE WITH VARIOUS KEY CONDITIONS AND PRIOR TRAINING

AP10267

		ACTUAL					ADJUSTED				
		PA	TA	BOTH	NONE	$\overline{X}$	PA	TA	BOTH	NONE	$\overline{X}$
NUMBER CORRECT (CATEGORY)	TRAINING	24.87	26.00	25.37	25.12	25.34	24.77	25.84	25.39	25.00	25.25
	NO TRAINING	24.00	23.12	24.37	23.75	23.81	24.10	23.28	24.36	23.87	23.91
	$\overline{X}$	24.44	24.58	24.87	24.44		24.36	24.52	24.86	24.45	
NUMBER CORRECT (SUB-CATEGORY)	TRAINING	18.25	18.25	16.88	16.63	17.50	17.96	17.74	17.02	16.38	17.27
	NO TRAINING	16.83	15.63	16.38	16.25	16.22	16.92	16.13	16.23	16.52	16.45
	$\overline{X}$	17.44	16.94	16.53	16.44		17.29	16.82	16.67	16.66	
TIME (MINUTES)	TRAINING	53.18	65.85	65.38	22.73	51.78	51.87	65.88	64.25	21.65	50.92
	NO TRAINING	60.73	65.95	69.68	17.10	53.37	62.07	65.92	70.82	18.18	54.25
	$\overline{X}$	56.87	65.90	65.53	19.92		58.13	65.90	67.20	19.43	
LOG TIME	TRAINING	1.71	1.81	1.80	1.33	1.66	1.70	1.81	1.80	1.32	1.66
	NO TRAINING	1.78	1.81	1.84	1.20	1.66	1.79	1.80	1.85	1.27	1.66
	$\overline{X}$	1.75	1.81	1.82	1.28		1.78	1.80	1.82	1.28	
EFFICIENCY (CATEGORY)	TRAINING	.49	.42	.41	1.25	.64	.52	.38	.42	1.27	.65
	NO TRAINING	.41	.38	.36	1.60	.68	.38	.39	.34	1.58	.67
	$\overline{X}$	.45	.39	.38	1.42		.42	.39	.40	1.44	
EFFICIENCY (SUB-CATEGORY)	TRAINING	.33	.29	.27	.82	.44	.37	.28	.28	.83	.44
	NO TRAINING	.28	.25	.25	1.10	.47	.27	.26	.23	1.09	.46
	$\overline{X}$	.32	.27	.26	.96		.32	.27	.30	.97	

TABLE 9 SUMMARY ANALYSIS OF COVARIANCE RESULTS

AP10273

	TRAINING CONDITIONS				KEY UTILIZATION CONDITIONS				
	R*	TRNG	NO TRNG	SIG LEVEL	PA	TA	BOTH	NO KEY	SIG LEVEL
NUMBER CORRECT (TARGET CATEGORY)	.24	25.25	23.81	.05	24.36	24.52	24.98	24.45	NS*
NUMBER CORRECT (TARGET SUBCATEGORY)	.45	17.27	16.45	NS	17.29	16.82	16.67	16.66	NS
TIME (IN MINUTES)	.33	50.92	54.25	NS	58.13	65.90	67.20	19.43	.01
LOG TIME	.36	1.66	1.66	NS	1.78	1.80	1.82	1.28	.01
IDENTIFICATION EFFICIENCY (TARGET CATEGORY)	.32	.65	.67	NS	.42	.39	.40	1.44	.01
IDENTIFICATION EFFICIENCY (TARGET SUBCATEGORY	.17	.44	.46	NS	.32	.27	.30	.97	.01

μ INDICATES CORRELATIONS BETWEEN PRE-TEST AND KEY TEST ROLL SCORES FOR SIX DEPENDENT VARIABLES

└──┘ : INDICATES SIGNIFICANT MEAN DIFFERENCES ($P < .01$) (NEWMAN KEULS TEST)

the results obtained in the Training study -- that those subjects given training using the structured presentation of key data base material were better able to identify targets at this more gross level of interpretation than those not given training. The other nonsignificant differences are also in line with the previous findings. No significant training by key condition interactions were found, indicating that key performance was not differentially affected by previous exposure or lack of exposure to the data base.

From Table 9 it may also be seen that when comparing performance among the the four key utilization conditions, significant differences were found for Time, Log Time, Identification Efficiency (Target Category), and Identification Efficiency (Target Subcategory); no significant difference were found among the four key utilization conditions for Number Correct (Target Category) and Number Correct (Target Subcategory).

As was pointed out earlier, interpreter subjects in all three conditions involving the use of keys were required for each identification they made the "block" number of the representative image (given beside each image on a chip) they used in helping them make their identification, i.e., they were forced to refer to the data base, even if they did not feel the requirement to do so. It was expected, therefore, that significant differences would be found for those variables involving time and that, in particular, the No Key condition would take much less time than the other three conditions.

The performance scores (at both the target category and target subcategory level) did not show differences among the four key utilization conditions. Thus, from the conditions of this experiment it was not possible to show that one key type or combination of the two resulted in better identification performance than that achieved by interpreters without reference aids to help them.

To investigate further any relevant differences between the key utilization conditions an analysis was conducted of the number of requests for slides made for the three key utilization conditions. For similar identification performance the key utilization condition requiring the fewest number of slides to be requested should be considered the most efficient organization of the three conditions. The number of requests made by each group are shown in Table 10.

TABLE 10 MEAN NUMBER OF SLIDES REQUESTED BY THE EIGHT SUBJECTS IN EACH CONDITION*

AP10240

	PA	TA	BOTH	$\bar{X}$
TRAINING	36.50	48.25	50.00	44.92
NO TRAINING	42.00	53.50	55.13	50.21
$\bar{X}$	39.25	50.88	52.56	

*MINIMUM NUMBER OF SLIDES THAT COULD BE REQUESTED EQUALED 30; ONE PER TARGET TO BE IDENTIFIED.

This requirement was imposed on the experimental subjects, as previous attempts to evaluate different key organizations and contents showed no significant differences in identification performance when interpreter subjects were free to use keys only when they wished to do so. Observations during the conduct of the earlier experiments led to speculation that the lack of significant results might be, at least in part, attributable to subjects not using the experimental keys when it would have been to their benefit to do so. To prevent this from occurring, the present study incorporated the enforced condition which, even though creating a somewhat artificial task for the subjects, insured that the keys would be used. The number in the No Training-PA cell does not represent the true number of slides called. One of the eight subjects in this group was found to account for 176 of the 470 slide requests made. Therefore, a mean was calculated for the other seven subjects and this mean added to the total for seven other subjects in the cell.

However, a 2 X 3 factorial analysis of variance showed that the differences were not statistically significant, as shown in Table 11. While mean differences appear to be fairly large, there were relatively large individual differences in number of slide requests made which did not permit a clear-cut indication of the efficiency of any one Key condition.

TABLE 11 ANALYSIS OF VARIANCE TABLE FOR NUMBER OF SLIDES REQUESTED

SOURCE	SUM OF SQ	df	MEAN SQ	F	SIGNIFICANCE
TRAINING	488	1	488.0	1.448	NS
KEYS	1631	2	815.5	2.420	NS
TRAINING X KEYS	10	2	5.0	.0148	NS
ERROR	14156	42	337.0		
TOTAL	16285	47			AP10239

In this study the use of the material during the interpretation task required of the subjects (identification of annotated images) did not improve identification performance at either level of identification. However, significant differences between the Training and No Training Groups were still obtained for identification performance at the category level. The results support the notion that key material, such as that used here may be used effectively for training purposes, serving to familiarize interpreters with targets they will be called upon to identify. That significant differences between the Training and No Training groups were also obtained during the Keys study would attest to their value as a training or familiarization aid, not as an aid during interpretation, unless the interpreter may desire limited use of the data base during interpretation or as required to perform detailed interpretation.

SUMMARY

This report has discussed the design of a reference information data base within the context of a future, computer-based tactical imagery interpretation facility. The intent has been to study the requirements of the interpreter in the field for reference information and to analyze methods for meeting these operational needs. The emphasis has been to consider a reference information data base for use as interpreter key material during operational interpretation, as well as for training material for on-site instruction. In the latter instance, data base material would be used to provide interpreters with training in the field that would supplement their school training and would offer specialized training for different sensors or areas of assignment.

For the purpose of the analysis, it is assumed that the future facility will contain a general purpose digital computer, associated CRT-keyboard input/output equipment, and a store of reference information in the form of standard 70 X 100 millimeter chips.

Certain of the conclusions to be discussed below have been arrived at on the basis of analysis. Others are based upon the results of the experimentation performed. On the basis of this analysis, it was concluded:

1. Reference material whose value decreased as a function of time -- prior coverage and previously prepared interpretation reports -- should be indexed for rapid retrieval but stored in their original form.

2. Reference material whose value remains constant -- maps and key material -- should be stored in a unit record format (e.g., on a 70mm X 100mm chip) for speed of retrieval, for rapid accessioning; and for minimizing the bulk of material to be stored.

3. Microform technology offers a method of storing large amounts of information on a single piece of film. Consideration should be given to the investigation of the use of microfiche for storing and displaying reference information. In this manner each interpreter station could economically be provided with a complete set of map and key reference material and would prevent the situation where more than one interpreter desired the same information from the data base.

4. Requirements for interpreter key material and on-site instructional material led to the delineation of three types of information organization that could be used within the keys portion of a reference information data base. Two portions, containing primarily representative imagery examples, differ in the organization of the material, while the third presents a different type of information -- primarily textual. The three sections proposed for consideration are:

    Parameter Accession: a single image of each target type is presented under one set of acquisition parameters.

    Target Accession: images of a single target type are presented under all acquisition conditions.

Detailed Target Information: primarily textual material that covers target description, enemy employment, misidentification, errors, effects of weather, and effects of imagery degradation.

Reference material organized for Parameter Accession provides simultaneous viewing of several targets under one set of acquisition parameters and can be used to compare a signature on operational imagery with a variety of possible targets; material organized for Target Accession can be used for analysis of a single target type under a range of acquisition conditions. Detailed Target Information can be used for detailed target analysis.

5. An indexing technique is proposed that meets the criteria of simplicity, inclusiveness, flexibility and possessing mnemonic qualities.

6. Information request formats similar to those described could be used for inputting retrieval criteria by the image interpreter. These formats have been designed to minimize interpreter effort in inputting his retrieval requests.

7. The computer within a future facility should have the capability for searching stored reference information index records (including those for prior cover and interpreter reports) in line with the interpreter's retrieval request and outputting on the CRT those records meeting the retrieval criteria.

8. The data base, if it is to be of maximum usefulness, must be "open-ended," i.e., there must be provision for expansion, as well as substitution.

9. Procedures for the use of the keys portion of the data base were suggested and related to operational interpretation as well as initial and refresher training. The extended discussion of these procedures has been included to indicate how this portion of the data base could be used within a future TIIFto improve interpreter performance significantly.

The experimental portion of this study, using infrared imagery interpretation as the interpreter's task within the simulated environment provided by the Information System Laboratory, permitted the simulation of key information display in an automated retrieval system.

The results indicated that such a data base may be used for effective training and familiarization. However, under the conditions of the experiments carried out, no significant differences in performance as a function of data base organization or access to the data base were obtained. Further research is required, utilizing different imagery types (i.e., photographic and SLAR in addition to IR) and a broader range of interpreter tasks to assess fully the value of the type of key data base outlined.

Use of such a data base did not lead to better interpretation performance than not having access to such a data base. Indeed, it required more time, as is to be expected, as the interpreter had to go through the steps required to use the data base. However, the task used may not have been appropriate for such utilization. A greater variety of tasks, experience level of subjects and expansiveness of data base is required before a definitive finding concerning the effectiveness of such a system can be made.

Though not formally evaluated, the reference information request formats and output formats (similar to those described in the analytical portion of the report) in conjunction with a keyboard-CRT computer interface were found to be efficiently handled by the experimental subjects with very little training. Interpreters were able to input their requests with few errors and after viewing the output formats showing those slides meeting their retrieval requirements, rapidly retrieved the desired key slide. Slides presented by means of rear-screen projection on a 25" X 32.5" viewing surface were easily viewed by the interpreters for training and during interpretation. This demonstration supports the notion that reference information can be indexed, requested, retrieved, and displayed quickly with computer assistance and that the proposed interpreter-computer interface can be used by interpreters to retrieve the desired information. While the demonstration was concerned only with the retrieval and display of infrared interpreter key information, it is reasonable to expect that such a scheme may be used for the retrieval of other types of reference information (i.e., maps, prior cover, interpreter reports).

APPENDIX A

TEST IMAGERY PARAMETERS

APPENDIX A

TEST IMAGERY PARAMETERS

PRETEST

Frame #	Identification Category	Subcategory	Altitude (Ft)	Time of Take	Detector Cell
1	Boat	Personnel	1000	Day	LWL
2	Personnel	--	1000	Day	LWL
3	Emplacement	Missile	500	Night	LWL
4	Boat	Ship	1000	Evening	LWL
5	Structure	POL Tank	2000	Evening	SWL
6	Emplacement	Light Weapons	500	Night	LWL
7	Non-Target	--	500	Day	LWL
8	Aircraft	Lt. Observation	1000	Night	LWL
9	Structure	POL Tank	2000	Evening	SWL
10	Fire	--	500	Night	SWL
11	Aircraft	Helicopter	500	Night	LWL
12	Personnel	--	1000	Day	LWL
13	Structure	Tent	1000	Night	LWL
14	Boat	Barge	1000	Night	SWL
15	Boat	Barge	1000	Night	LWL
16	Boat	Sampan	1000	Night	LWL
17	Emplacement	Artillery	500	Night	LWL
18	Non-Target	--	1000	Evening	SWL
19	Vehicle	Heavy Motored	1000	Night	LWL
20	Emplacement	Bunker	1000	Evening	SWL
21	Structure	Hut	2000	Day	LWL

Frame #	Identification Category	Subcategory	Altitude (Ft)	Time of Take	Detector Cell
22	Emplacement	Bunker	1000	Day	LWL
23	Structure	Bridge	1000	Night	LWL
24	Fire	--	2000	Day	LWL
25	Vehicle	Light Motored	500	Night	LWL
26	Emplacement	Artillery	500	Night	LWL
27	Vehicle	Light Motored	2000	Night	SWL
28	Vehicle	Heavy Motored	2000	Day	LWL
29	Structure	Hut	1000	Evening	SWL
30	Emplacement	Trench	500	Night	LWL
		POST TEST			
1	Boat	Barge	1000	Night	LWL
2	Boat	Ship	1000	Night	LWL
3	Emplacement	Trench	5000	Night	LWL
4	Structure	Tent	1500	Night	LWL
5	Structure	Hut	1000	Night	LWL
6	Structure	Bridge	1000	Night	LWL
7	Vehicle	Heavy Motored	1000	Evening	LWL
8	Emplacement	Artillery	500	Day	LWL
9	Non-Target	--	500	Night	LWL
10	Vehicle	Light Motored	500	Night	LWL
11	Emplacement	Trench	500	Day	LWL
12	Structure	POL Tank	1000	Night	LWL
13	Personnel	--	500	Night	LWL
14	Boat	Sampan	1000	Night	LWL

Frame #	Identification Category	Subcategory	Altitude (Ft)	Time of Take	Detector Cell
22	Emplacement	Bunker	1000	Day	LWL
23	Structure	Bridge	1000	Night	LWL
24	Fire	--	2000	Day	LWL
25	Vehicle	Light Motored	500	Night	LWL
26	Emplacement	Artillery	500	Night	LWL
27	Vehicle	Light Motored	2000	Night	SWL
28	Vehicle	Heavy Motored	2000	Day	LWL
29	Structure	Hut	1000	Evening	SWL
30	Emplacement	Trench	500	Night	LWL

POST TEST

Frame #	Category	Subcategory	Altitude (Ft)	Time of Take	Detector Cell
1	Boat	Barge	1000	Night	LWL
2	Boat	Ship	1000	Night	LWL
3	Emplacement	Trench	5000	Night	LWL
4	Structure	Tent	1500	Night	LWL
5	Structure	Hut	1000	Night	LWL
6	Structure	Bridge	1000	Night	LWL
7	Vehicle	Heavy Motored	1000	Evening	LWL
8	Emplacement	Artillery	500	Day	LWL
9	Non-Target	--	500	Night	LWL
10	Vehicle	Light Motored	500	Night	LWL
11	Emplacement	Trench	500	Day	LWL
12	Structure	POL Tank	1000	Night	LWL
13	Personnel	--	500	Night	LWL
14	Boat	Sampan	1000	Night	LWL

Frame #	Identification Category	Subcategory	Altitude (Ft)	Time of Take	Detector Cell
15	Structure	Hut	2000	Day	LWL
16	Fire	--	500	Night	LWL
17	Non-Target	--	500	Day	LWL
18	Vehicle	Light Motored	2000	Day	LWL
19	Structure	POL Tank	1000	Day	LWL
20	Emplacement	Artillery	5000	Day	LWL
21	Structure	Bridge	1000	Night	LWL
22	Aircraft	Lt. Observation	1000	Night	LWL
23	Aircraft	Helicopter	1000	Day	LWL
24	Vehicle	Heavy Motored	1500	Night	LWL
25	Fire	--	500	Night	SWL
26	Boat	Sampan	1000	Night	LWL
27	Aircraft	Helicopter	1000	Day	LWL
28	Fire	--	2000	Day	LWL
29	Boat	Ship	1000	Evening	SWL
30	Emplacement	Bunker	1000	Evening	SWL

KEYS TEST

1	Aircraft	Lt. Observation	2000	Night	LWL
2	Fire	--	2000	Day	LWL
3	Boat	Ship	1000	Evening	LWL
4	Structure	POL Tank	1000	Evening	LWL
5	Boat	Sampan	1000	Night	LWL
6	Structure	Bridge	2000	Evening	SWL
7	Non-Target	--	1000	Day	LWL

Frame #	Identification Category	Subcategory	Altitude (Ft)	Time of Take	Detector Cell
8	Emplacement	Bunker	1000	Night	LWL
9	Vehicle	Heavy Motored	2000	Night	SWL
10	Emplacement	Trench	500	Night	LWL
11	Structure	POL Tank	1000	Night	LWL
12	Boat	Barge	1000	Day	LWL
13	Emplacement	Artillery	500	Day	LWL
14	Personnel	--	500	Night	LWL
15	Structure	Tent	1000	Day	LWL
16	Personnel	--	1000	Day	LWL
17	Emplacement	Light Weapons	1000	Evening	SWL
18	Boat	Barge	1000	Night	SWL
19	Vehicle	Light Motored	2000	Day	LWL
20	Emplacement	Missile	1000	Night	SWL
21	Emplacement	Artillery	2000	Day	LWL
22	Boat	Sampan	1000	Night	LWL
23	Emplacement	Trench	500	Day	LWL
24	Vehicle	Heavy Motored	500	Night	LWL
25	Structure	Tent	1000	Day	LWL
26	Vehicle	Light Motored	500	Night	LWL
27	Non-Target	--	1000	Night	LWL
28	Structure	Bridge	1000	Night	LWL
29	Emplacement	Bunker	500	Night	LWL
30	Structure	Hut	2000	Day	LWL

APPENDIX B

ANALYSIS OF COVARIANCE RESULTS

TRAINING

APPENDIX B

ANALYSIS OF COVARIANCE RESULTS

TRAINING

Number Correct (Target Category)

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	22.406	1	22.406	4.835	.05
Error	282.700	61	4.634		
Total	305.104	62			

Number Correct (Target Subcategory)

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	9.348	1	9.398	1.619	NS
Error	354.183	61	5.806		
Total	363.582	62			

Time

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	.155	1	.155	.006	NS
Error	1658.301	61	27.185		
Total	1658.463	62			

Log Time

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	.000	1	.000	.000	NS
Error	.715	61	.012		
Total	.715	62			

Identification Efficiency (Target Category)

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	.073	1	.073	.764	NS
Error	5.827	61	.096		
Total	5.900	62			

Identification Efficiency (Target Subcategory)

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	.025	1	.025	.382	NS
Error	3.977	61	.065		
Total	4.002	62			

APPENDIX C

ANALYSIS OF COVARIANCE RESULTS

KEYS STUDY

Number Correct (Target Category)

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	27.843	1	27.843	5.672	.05
Key	3.606	3	1.202	.245	NS
Training X Key	8.253	3	2.751	.560	NS
Error	269.982	55	4.909		
Total	309.887	62			

Number Correct (Target Subcategory)

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	10.276	1	10.276	2.189	NS
Key	4.205	3	1.402	.299	NS
Training X Key	6.477	3	2.159	.460	NS
Error	258.199	55	4.695		
Total	278.547	62			

Time

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	169.714	1	169.714	1.097	NS
Key	24139.774	3	8046.591	52.014	.01
Training X Key	457.043	3	152.348	.985	NS
Error	8508.461	55	154.699		
Total	33220.376	62			

Log Time

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	.001	1	.001	.085	NS
Key	3.456	3	1.152	87.204	.01
Training	.086	3	.029	2.176	NS
Error	.727	55	.013		
Total	4.266	62			

Identification Efficiency (Target Category)

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	.011	1	.011	1.52	NS
Key	12.762	3	4.254	60.085	.01
Training X Key	.477	3	.159	2.247	NS
Error	3.894	55	.071		
Total	17.154	62			

Identification Efficiency (Target Subcategory)

Source of Variance	Sum of Squares	df	Mean Square	F	Significance
Training	.010	1	.010	.275	NS
Key	5.650	3	1.884	50.627	.01
Training X Key	.304	3	.102	2.722	NS
Error	2.050	55	.037		
Total	8.036	62			